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CONTENTS.

EDITORIAL: PAGE.
Paragraphs ... 329

ILLUSTRATED ARTICLES:
ELECTRICAL WORLD Portraits: Prof. J. A. Fleming ... 330
Electric Lighting of the Plaza Hotel ... 331
Electromagnetic Radiation, by Prof. Arthur L. Kimball ... 332
Electrical Distribution by Transformers from Central and Eccentric Stations, by Dr. J. A. Fleming ... 335
The Electromagnet, by Prof. S. P. Thompson ... 336
An insulated Binding Post ... 338
New Carbon Brush-Holder for Dynamos ... 338
A New-comer Among Motors ... 338
New Lightning Arrester ... 338
Investigation of the Stanley Alternate Current Arc Dynamo, by W. B. Tobey and G. H. Walbridge ... 339
A New Brill Truck ... 341
A New Arc Lamp ... 341

MISCELLANEOUS:
Schools of Electro-Technics, by Geo. Black ... 330
Experiments on Electrical Oscillations ... 330
Electro-Dynamics of Stationary Bodies, by H. Hertz ... 334
Statistics of Submarine Telegraphs ... 334
A Cable to Australia ... 334
An Important Decision in Pennsylvania ... 338
A Medical Examination by Telephone ... 338
Equipment of the "Trenton" ... 341

SPECIAL CORRESPONDENCE: New York Notes, 342; New England Notes, 342; Philadelphia Notes, 342; Western Notes, 342; English Notes, 342.

NEWS OF THE WEEK: The Telegraph, 342; The Telephone, 342; The Electric Light, 342; Applications of Power, 343.

INDUSTRIAL AND TRADE NOTES ... 343
ANSWERS TO CORRESPONDENTS ... 343
BUSINESS NOTICES ... 343
OUR ILLUSTRATED RECORD OF ELECTRICAL PATENTS ... 343

The Subway Situation. DIFFICULTIES innumerable seem to beset the extension of electric lighting and power distribution in this city. So serious has the situation become that at a recent meeting of the Board of Electrical Control pole rights were granted in the upper part of the city, in response to dire necessity. The history of the subways in this city is one long story of mismanagement, political jobbery and malicious machinations. We sincerely hope that the next two years will not, at least, serve to repeat the mistakes and worse that have given the past such an unenviable reputation. It is high time for reform by whomsoever it may soonest come. Give the electric lighting companies a fair show—their work is too important to be obstructed and delayed.

A Distinguished Engineer. WE are glad to publish this week the portrait of Dr. J. A. Fleming, whose brilliant articles on the applications of alternating currents, contributed to the London *Electrician*, we are now reprinting on this side of the Atlantic. Dr. Fleming's services to applied electricity during the last decade have been great, for he has at once been the champion of progress and of education. His little volume of "Lectures to Electrical Artisans," published a few years ago, is a model of popular instruction, and is certainly unrivaled by anything that has appeared on the subject in this country We Americans are sometimes apt to forget, in witnessing the immerse growth of the applications of electricity in our country, how much we owe to our cousins of the little island across the mill-pond; and it is sometimes well to stop and think of where the theory of electricity, on which its applications depend, would be to-day except for their assistance—not that Americans have not done admirable work in developing the principles of electricity—but without Maxwell and Thomson, and Hopkinson and Lodge, and half a dozen others we might name, there would be to-day much less prospect for the future than we are blessed with as it is.

Concerning Air Ships. THERE seems just now to be a spasmodic boom in aerial navigation. It is a subject so fascinating from every point of view that we can little wonder at its being cherished by numberless inventors. Of late years the clever experiments of Tissandier and others have made it evident that it is possible to drive a balloon at a fair rate of speed, and to steer it with a tolerable degree of success. Nevertheless, much as we may trust in the advances of the past as an augury of the future, we must recognize the unique difficulties of the task. In the first place the structure must be immensely strong and light to withstand the strains to which it will be subjected and to permit of any useful lifting power. Hydrogen gas represents the limit so far as the principle of flotation is concerned, for it is by all odds the lightest gas. Rarified air is simply a very bad substitute for it, necessitating a rigid and heavy envelope to stand the pressure from without, without any compensating advantages. Given then an enormous spindle-shaped balloon inflated with hydrogen, is there a reasonable probability that it can be managed safely and be given fair speed? To this we may say yes, provided there is little or no wind. But it must be remembered that a wind velocity of fifty or sixty miles an hour is by no means infrequent, particularly at considerable altitudes, and to withstand such a gale, with any chance of success, the airship must be provided with machinery that will drive it at something greater than the highest speed ever reached by an ocean steamer. To a certain extent such dangerous gales might be avoided by a change in elevation, but it is only too evident that the difficulty is a most serious one. No motive power yet devised gives much hope of accomplishing the task, and while, perhaps, it is too much to say that there is no hope of finding one, it is well to recognize that the difficulties differ both in degree and kind from those encountered in any other mechanical problem. Even if they can be overcome, by the aid, for instance, of an enormously powerful electric motor and storage battery, the general usefulness of the result may still be called in question.

An Arc Light Alternator. THE very exhaustive study of the Stanley arc light alternating machine recently adopted by the Westinghouse Company will be a revelation to very many of our readers. It is a curious thing that while the alternating machine was first in the field and operated the Jablochkoff candles, the first type of arc lamp which came into anything that might fairly be called commercial use, it was soon replaced by continuous current machines, and only recently has regained anything of its early prestige. It is the marvelous flexibility, so to speak, of the alternating current that has brought it recently into deserved prominence, and this is nowhere better exemplified than in the Stanley machine. It has long been known that a series wound continuous current dynamo could be built which would give a very rough approximation to a constant current, but though experiments in that direction were made by the great European firm of Siemens no practical machine resulted. This problem of automatic constant current regulation, apparently insoluble for continuous currents, has met with a complete answer in the Stanley alternator. From no load up to full load the machine is almost absolutely self-regulated; an ampère or two represents the entire variation from short circuit to open circuit, while the response to a change of resistance is complete and instantaneous. A glance at some of the cuts representing the electrical peculiarities of this machine shows better than any words can do the perfection of the regulation. Fig. 11, of Tobey & Walbridge's paper, given on another page, is conclusive. Inasmuch as the resistance of the electric arc depends on the formation of carbon vapor in and about the space between the poles, it must vary according to the amount of current passed; at the start, when the arc is first formed the resistance is high, consequently at the beginning of the period of the alternation the electromotive force of the machine, instantly responsive to the resistance, rises to a sharp peak, and then as the arc is established and its resistance falls, it drops again to rise once more at the end of a semi-oscillation, and establishes itself on the reversal, as before. There could be no better evidence of the way in which the peculiar armature construction serves as a method of regulation. Mr. Stanley's own explanation of the action of the machine, given in the discussion which followed the paper in question, gives a clear idea of the details of the action. Another extraordinary feature of this dynamo is its efficiency curve which, as will be seen, touches 90 per cent. at less than half load, and then rises very slowly up to full load. This is a most remarkable and valuable property of the arc light alternator, and means a high all-around station efficiency at all ordinary loads. Taken altogether, Mr. Stanley has certainly succeeded in devising a very valuable means of extending our power of distributing electrical energy conveniently and efficiently.

Electrical Radiation. IT is now a quarter of a century since James Clerk Maxwell first enunciated the prophetic theory that light is but the form of electrical energy, and the complete proof of this brilliant suggestion was for years a dream of experimenters. For such a proof not only would link together the phenomena of two far-reaching branches of physical science, but would give an insight into the nature of electrical energy that could not be obtained so long as its investigation was confined to purely electrical methods. As a consequence, it might well have been expected that as the truth of the great physicist's surmise gradually become more and more evident up to the time of its magnificent demonstration by Hertz, our views of electricity would have been undergoing profound changes and modifications, putting complicated phenomena in a clearer light than ever before. During the last decade the new views of electricity have been expanding with immense rapidity. The admirable paper by Prof. Kimball, elsewhere in these pages, takes up and explains in the simplest form practicable some recent conceptions of electricity and electrical action. To those already familiar with the subject it will at once appear that Prof. Kimball is a close follower of the views laid down by Lodge in his recent book on "Modern Views of Electricity." There is something exceedingly fascinating in the explanation of electrical phenomena by fluid motion. The fundamental idea is an old one, bnt until very recently it has never been put in such a form as to commend itself to the investigator. The fluid theory of electricity certainly expresses observed facts in a remarkably satisfactory way, but in the form given by Lodge it must be confessed that it involves some colossal hypotheses. In fact, the two-fluid theory almost compels us to believe that the ether is a complex body consisting of positive and negative electricities ordinarily united but capable of being brought into individual action by means at our command. Up to the point where such a conception as this is introduced into the theory the hydro-dynamic method of viewing electrical phenomena is immensely convenient, but as soon as this latter addition is made to it we find ourselves face to face with considerable difficulties. On this view, for example, we have a universal medium of indefinitely increasing complexity, and if we accept the view that each atom carries a charge of positive or negative electricity, in virtue of which it has chemical affinities, we find ourselves in the unpleasant dilemma of either being compelled to assume the action at a distance which it has been the constant aim of modern physicists to avoid, or else to invoke a still further complication in the individual electricities; in other words, if we account for chemical action by electrical attraction, how do we explain the latter? Given an ether made of two electricities, does not the explanation of the inter-action between them involve all the complications that now beset the inter-action between ordinary atoms? It very much appears as if in changing the place the pain had been retained. These suggestions are made merely by way of showing that we must not be too literal in our application of hydro-dynamic principles to electricity, for these apply equally well to nearly all cases where there is a continuous flow of whatever kind, whether a material fluid, electricity, or that mode of motion which we denominate heat. Satisfying the conditions of hydro-dynamics is therefore only circumstantial evidence of anything like a true material nature. Therefore, while availing ourselves to the utmost of the help that hydro-dynamics can give us in interpreting electrical phenomena, it is best to do so with a mental reservation and a consciousness that we may some time awaken to find a closer linking together of all sorts of physical forces than we dream of to-day. To tell the truth, of electricity, about which we are wont to speak glibly enough, and which we introduce into our equations quite as a matter of course, we know, directly, absolutely nothing whatever. Concerning electrical energy we know much; but the factor of it which we call electricity eludes alike our senses and our intelligence. From a practical point of view, electricity is hardly more than a mathematical coefficient of which we may in due season earn the physical significance.

Electrical World Portraits.—XVII.

PROF. JOHN AMBROSE FLEMING, M. A., D. SC.

Dr. J. A. Fleming, whose name is now a familiar one to every electrical engineer, was born at Lancaster, England, 41 years ago, and is, like most of the well-known English electrical engineers, the possessor of a thorough scientific education. He studied first at the University College School of London, and then, at the age of seventeen, matriculated at the University of London, then, as now, prominent in the line of applied sciences. The young student's object then was to fit himself for civil and mechanical engineering as a profession, and, indeed, after completing his general work at the University College, he was for a short time connected with a firm of marine engineers, but he soon returned to London to resume his scientific studies, and took his degree of bachelor of science at the University of London in 1870. Subsequently, to further develop his scientific training, he entered the Royal College of Chemistry, and, after completing the courses of laboratory instruction, was appointed demonstrator at the advanced laboratory, and later he was private assistant to Dr. Franklin, well known as one the ablest chemists England has produced. It was at this time, perhaps, that Mr. Fleming's attention was more especially attracted to electrical studies, through some investigations in which he assisted the late Professor Guthrie. Soon after he obtained an appointment to lecture on physics and chemistry at Cheltingham College, but, feeling the necessity of a mathematical training that is so indispensable to the thorough study of electrical engineering, and being desirous of working under Clerk Maxwell at the then new Cavendish laboratory at Cambridge, he soon resigned this academic appointment and entered St. John's College at Cambridge as exhibitioner. Here, after distinguishing himself in his chosen branch of research, he was elected one of the foundation scholars and obtained several prizes, especially the Hughes prize, awarded to the foundation scholar most distinguished in natural philosophy in his year. After taking the degree of doctor of science at the University of London, he received his Cambridge degree with the first class on natural science tripos. During this period of study at Cambridge he was closely connected with Prof. Clerk Maxwell in various electrical researches, and especially carried out the elaborate comparisons of the proper standards of resistance which then were the order of the day in connection with the establishment of scientific standards. In doing this he designed a form of resistance appliances for an accurate and ready comparison of standard resistance coils, which has since been in use at Cambridge and other laboratories, a copy of which is now in the Electrical Standards Bureau of Johns Hopkins University at Baltimore. When the University College of Nottingham was founded in 1881 Dr. Fleming was appointed out of a large number of candidates to the chair of mathematics and physics and assisted in the preliminary organization of the institution. The next year his attention was turned to the then new field of electric lighting, and by the advice of friends he resigned his professorship and moved to London, and at the formation of the Edison Electric Light Company, of England, Dr. Fleming was appointed electrician for the company, and immediately began the researches on practical electricity which have made the high reputation he now has. On the amalgamation of the Edison Electric Light Company with the Swan Company in 1883 he was appointed advising electrician to the new organization, and has retained that place until the present. He was elected a fellow of University College, of London, in 1882, a fellow of St. John's College, at Cambridge, in 1883; and also a member of the Institution of Electrical Engineers and the Physical Society of London. He has served in the councils of both bodies; and at present is also a member of the British Association Committee on Electrical Standards. In 1885 he was appointed professor of electrical engineering of University College, London, which chair he holds at the present time. His researches have been numerous and important, and the titles of some of the well known ones may serve as an index to the character of his work:

The new contact theory of the galvanic cell.

The decomposition of an electrolyte by magneto-electric induction.

The polarization of electrodes in water free from air.

Magnetic induction in liquid circuits.

A form of resistance balance for comparing standard coils.

The characteristic curves and surfaces of incandescent lamps.

Problems in networks of conductors.

On molecular shadows in incandescent lamps.

On the use of Daniell's cell as a standard of electromotive force.

On a design for a standard resistance coil.

On electrical discharge between unequally heated lectrodes.

These papers have appeared in the proceedings of the Physical Society of London; the proceedings of the Royal Society, and of the British Association. He has also published papers and lectures on:

"Electric Lighting in Works and Factories," read before the Iron and Steel Institute;

"Problems in the Physics of an Incandescent Lamp," a discourse delivered before the Royal Institution;

"Elihu Thomson's Electromagnetic Repulsion Experiments," read before the Society of Arts, and awarded the silver medal of the society;

And an address on "The Necessity for a National Standardizing Laboratory for Electrical Instruments."

In particular, this address on the necessity for a national standardizing laboratory for electrical instruments, read before the Institution of Electrical Engineers in 1885, gave the initial impulse to the movement which has resulted in establishing a government laboratory for electrical testing. So keen an interest was taken in Dr. Fleming's suggestions that an influential committee was appointed, and made such representations to the Board of Trade that it resulted in the equipment of a government electrical laboratory for the verification and testing of standard measuring instruments.

Dr. Fleming has also served on committees of the Institution of Electrical Engineers to deal with various practical subjects connected with electric lighting, and has made himself intimately acquainted with the state of the art in England, and in other countries. In 1886 he published a volume of lectures entitled, "Short Lectures to Electric Artisans," which is to-day perhaps the best introduction to the study of electrical engineering, and a little later the first volume of a treatise on the "Alternate Current

PROF. JOHN AMBROSE FLEMING, M. A., D. Sc.

Transformer in Theory and Practice," which has placed the distinguished author in the front rank of investigators in that most important and fascinating line of work. This book is, to-day, our only thorough discussion of the alternating current phenomena, and the second volume which is now being published in the London *Electrician*, and reprinted in THE ELECTRICAL WORLD, will shortly be issued, covering the practical applications of the alternating current as the former treatise did the theory. Dr. Fleming has been an active investigator in the department of electrical measuring instruments, and has added to our resources for the measurement of electrical constants several admirable instruments. From his intimate connection both with educational and commercial interests, he has been in a position to be of great service to the cause of practical electrical education, and has been untiring in his efforts to further the advance of the science to which he has devoted so large a part of an exceedingly useful life. His investigations are continuing with unabated activity, and we may safely look for further and greater additions to our knowledge of electrical theory and practice.

Schools of Electro-Technics.

BY GEORGE BLACK.

With your permission I will add a few remarks to the discussion regarding the education of electrical engineers. Prof. Woods has expressed very clearly the difficulties which present themselves to me. Desiring information on the subject, I obtained the calendars of several technical colleges with a view to select a place for my boys, who propose to follow that profession. I was struck with the diversity of the studies as well as the great difference in the entrance examinations. Out of the number I have selected three; partly from their published reports and partly from the reputation which those establishments have earned in the other technical courses, they will represent the others. One has a special electrical engineering course, a second trains all as mechanical engineers—taking in a liberal course of modern languages, physics, chemistry and applied electricity. The third and largest institution gives the electrical engineer the same course as the mechanical engineer for three years, and diverges in the fourth, substituting physical laboratory work, applied electricity and electrical engineering for the mechanical engineering work proper of that year, and grants the degree of M. E. with Electrical Engineering specially marked in the diploma. Others, again, separate the two courses more, diverging after the first year, and giving a fuller course in physics, especially applied electricity. I confess I am at a loss to select a college, and failing to do so, the preparatory work is at a disadvantage, as each requires different attainments and different text books for entrance, and one particularly requires 60 per cent. in all subjects to pass.

I may mention that we have now two such schools in Canada: The School of Practical Science—affiliated to the Toronto University—and the McGills College Department of Applied Science, at Montreal; both have this last year erected large workshops, etc.

I trust that those competent to throw light on this subject will do so, as it is no doubt a matter of interest to many of your readers. Surely an assimilation of matriculation subjects might be agreed upon by the various universities, so that preparatory schools and students could have a choice of colleges. The colleges are not local institutions, but draw their students from all over the United States and foreign countries.

In your editorial remarks you draw a distinction between an "electrical engineer" and an "electrician." I would like some one to define the qualifications of the latter; the term is about as indefinite as "captain."

Experiments on Electrical Oscillations.

Long before the experiments of Hertz on electrical waves opened a new and magnificent field of investigation, it had been known that the discharge of a Leyden jar was distinctly oscillatory in its character, but with the recent theoretical developments this fact had assumed an importance little dreamt of a few years since.

Professor John Trowbridge and W. C. Sabine, of Harvard University, have recently been experimenting on some of the occult phenomena that occur during electrical oscillations in air, and their results are so interesting that they are well worth detailing here. The fundamental experiment consisted in obtaining a rapidly oscillating discharge from a Leyden jar and photographing the oscillations. Of course, if the sensitive plate was simply exposed to the spark a simple image would be obtained which would convey no idea of the real nature of the discharge. If, however, the spark is allowed to fall on a mirror revolving with great velocity, the reflected image will be slightly displaced by the rotation of the mirror while the oscillations are going on, so that what is to the eye a single spark will be drawn out into a band of light on the plate. If the discharge were a single rush of electricity this band of light would be continuous. But, however, since it consists of oscillations there would be found after the plate is developed a series of direct bands interrupting the nearly continuous line of light. These bands indicate the lengths of the successive oscillations. This experiment was first tried years ago and has recently been repeated. But the results obtained from it have a new interest in it in view of the work of Hertz, and the authors of the paper referred to take it up anew with improved apparatus.

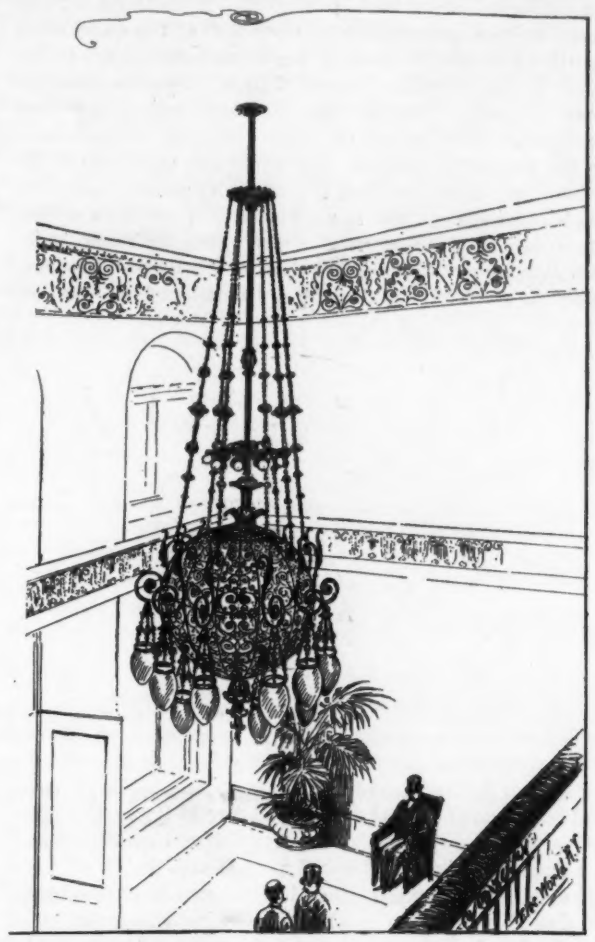
In reasoning on the mode of electrical oscillations in dielectrics, it occurred to them that the particular dielectric medium must influence the result obtained. At the moment of the electrical oscillations the glass of a Leyden jar, for instance, is subject to a strain which is more or less periodic. Inasmuch as it is not probable that the capacity of a condenser is the same for rapid charges and slow ones, and the ordinary methods of testing capacity do not give any clue to the result for very rapid charges and discharges, it was thought best to employ an air condenser instead of a Leyden jar, so as to detect, if possible, the effect of the medium on the electrical oscillations occuring in it. The condensers employed were concentric cylinders of zinc, of which the capacity could be quite readily computed. The condenser was furnished with a discharging circuit about 50 feet in length, and was charged by a Holtz machine. The revolving mirror was spinning on a horizontal axis at the speed of 3,000 revolutions per minute. The frame which carried it bore also a little brush which determined the moment of discharge of the condenser, so that at the time the electrical oscillations were set up the image of the spark should fall on the photo-

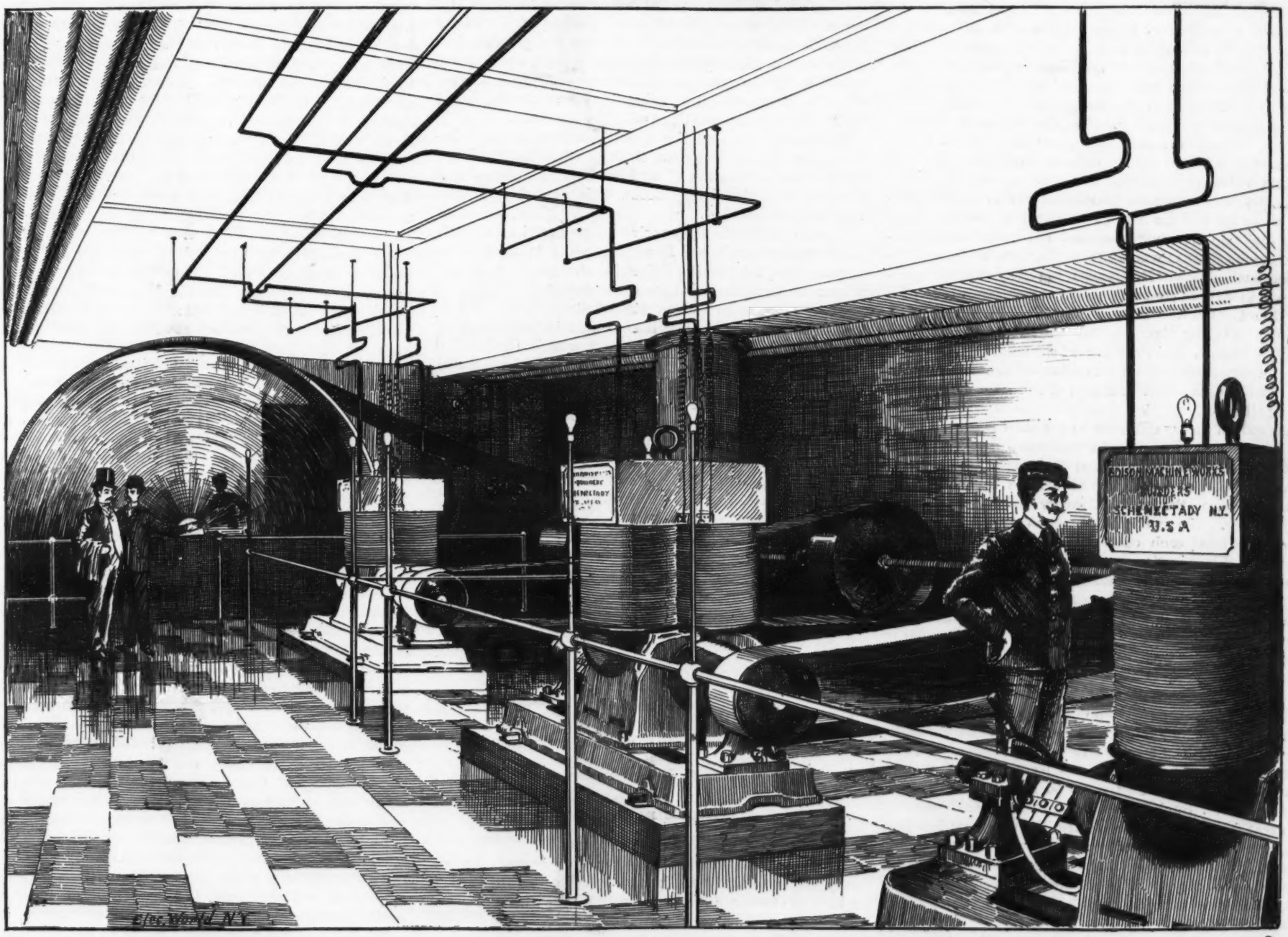
graphic plate. A concave mirror reflected the image of the spark to the revolving mirror. Some difficulty was met in the breakage of the mirror from its enormous velocity of rotation, but in spite of this experiments were carried to a successful conclusion.

The great difficulty was in getting the air condenser to be discharged at exactly the moment when its image fell on the photographic plate. This may be better appreciated when it is stated that the speed of the image in crossing the plate was about one mile per second. The period of the oscillations measured was, approximately, two or three millionths of a second. Glass Leyden jars were tested in addition to the air condensers. Now the curious part of the result of this experiment is that in the air condenser there was found the singular variation in the times of successive oscillations. It might have been expected at the start that a solid like glass would be much more likely to show such variations. On the contrary, these periods of the discharges from the glass condenser were extraordinarily regular, while those in the air showed decided discrepancies from the theoretical time of oscillation as determined from the capacity of the condensers and the self-induction of the circuit through which they were discharging. With a very small air condenser, apparently the air did not have time completely to recover in the time of a single oscillation from the strain to which it was being subjected. With a larger air condenser and, consequently, slower oscillations, the variations were much less marked.

According to the authors the reason the phenomenon was not observed in glass was because the period of recovery from a strain in that dielectric is too long to show itself during the enormously rapid oscillations with which the experiments were tried. The conclusion reached was that, in the first place, the electrical oscillations in air show a certain periodicity in their lengths, due to the incomplete recovery of the air from the electrical strain. It also appears that there is a certain amount of the energy of the discharge is spent in overcoming the dielectric viscosity of the air just as a certain amount of energy is spent in hysteresis in a magnet. Owing to this fact the theoretical equations of electric oscillation do not hold for air, just as we might find discrepancies in magnetic phenomena due to hysteresis. We have then probably, a true transformation of the energy of electrical oscillations in air into some other form of energy just as in the case of sound waves we have a certain transformation of energy due to heating and cooling the air as the wave passes along. We have much yet to learn concerning the real mechanism of electrical oscillations, but experiments like these cast a great deal of light on the very complicated phenomena that accompany electrical discharges in ordinary dieletrics. A further experiment was tried by the authors with a view of testing the effect of an intense magnetic field on these electric waves. It might be supposed that a certain amount of the energy spent in producing the oscillations would be consumed in the reaction on this magnetic field. The results, however, were indecisive, although it is possible that with further improvements in the apparatus the effect on displacement currents may render itself and them manifest.

The merest casual glance at experiments like these will show the importance of the theoretical field that is opened to our view, and it is to be hoped that the authors will continue their researches.





DYNAMO ROOM AND GREAT ELECTROLIER OF THE ELECTRIC LIGHT PLANT AT THE PLAZA HOTEL.

Electric Lighting of the Plaza Hotel.

Perhaps no class of buildings in New York City is so admirably fitted with electric lighting plants as the hotels and theatres. Several of these plants which seem to possess considerable merit have been illustrated in our columns from time to time. In the present issue we are able to present an interior view of the dynamo room of the new Plaza Hotel, situated at the corner of Fifth avenue and 58th street, New York City.

The dynamo room is located in the basement of the building and is very large and coveniently arranged. Its size is about 40 x 100 feet. The dynamo plant consists of four No. 16 Edison machines of 650 lights capacity each. These are driven by two Whitehill-Newburgh Corliss engines of 75 h. p. each. All the machinery is surrounded by brass railings, and at each opening through the railings there are two upright brass posts, on the tops of which are placed 16 c. p, electric lamps, as is shown in the large illustration on this page.

The floor of the dynamo room is of polished marble, white and gray in color, and, although very handsome in appearance, it does not give the best satisfaction, owing to the fact that the insufficient ventilation of the room causes the temperature to reach a rather high point, and this keeps the marble floor hot at all times, producing somewhat unpleasant results.

The circuits running from the dynamos to the lights throughout the building are provided with switches in each hallway, and also in the dining room, billiard room, café and other rooms, and these are concealed in the woodwork or decorations of the room. The wiring, which is all admirably done, is the work of the Tucker Electrical Construction Company of this city.

The fixtures throughout the building are very handsome, and are designed with special reference to the decorations of the various rooms in which they are placed. The large and very elaborate electrolier which hangs in the main corridor is shown in the accompanying illustration. This is made of wrought iron, and contains thirty-six 50 c. p. lamps. The large globe in the centre of the electrolier is of stained glass and contains several lamps, which, when lighted, produce a very brilliant effect. The fixtures throughout the building are the work of the Bergmann Electric and Gas Fixture Company. The entire plant since its inauguration has given the very best satisfaction, every circuit in the building being in perfect order from the start. The engines and dynamos, and in fact all of the arrangements of the dynamo room, are doing excellent service.

Electromagnetic Radiation.

BY PROFESSOR ARTHUR L. KIMBALL, PH. D.

It is an interesting fact that the old notion that electricity is a substance, one of the so-called class of imponderables held by the earlier investigators of electrical phenomena, after being generally supposed to be dead and buried, should be resurrected and in a dress to suit the times should become a part of the orthodox scientific creed of to-day. Yet this is the case. The discovery that heat, instead of being a substance, caloric, is the energy of motion of the particles of a body, together with the establishment of the principle of the conservation of energy, led to the idea that perhaps electricity was also in some way a form of energy. It is apparent, however, that this view is untenable, for there is this striking difference between the case of electricity and that of heat, in that a given amount of heat is always equivalent to the same amount of energy whether it is in a hot body or a cold body, whereas the amount of energy which a given quantity of electricity possesses depends entirely on its potential, or voltage. Faraday's experiments, by which he established that a battery cell smaller than a lady's thimble could develop a quantity of electricity more than enough to stock a thunderstorm, are especially significant because there can be no question that the energy of the lightning flash is immensely greater than that of the feeble current from the tiny cell. The difference is obviously due to the enormous electrical pressure, or potential, in the case of the lightning as contrasted with the very feeble voltage of the single cell. Such considerations make it evident that electricity is not energy, though, undoubtedly, it requires energy to charge a body or to keep up an electric current. The view most widely accepted at present is that electricity is a substance.

But in saying this it is not intended to convey the idea that like ordinary matter it has weight and is subject to gravitation attraction, or that it exhibits what the text books call impenetrability; that is, that it excludes ordinary matter from the regions which it fills. It is rather to be conceived as a substance in the same sense as the luminiferous ether is a substance; that is, that it is an entity which is never transformed or changed into anything else, and so is indestructible and its total amount unchanged. Whether it is subject to gravitation attraction and so has weight is entirely unknown. What is ordinarily called a vacuum, such as the interior of an exhausted vessel or the regions of interstellar space, is filled with the ether, the medium which conveys light, and it is believed that electricity is a most important constituent of this ether. Possibly there are two kinds of electricity, and the two combined make up the ether somewhat as oxygen and hydrogen combine to form water; there are facts which seem to support such a view. But passing over the difficult question whether there are two kinds of electricity or only one, a good idea of the way in which electrical actions are now regarded as taking place may be obtained by assuming the one fluid theory, and thinking of electricity as an absolutely incompressible fluid pervading all ordinary matter, as well as being a constituent part of the ether and so pervading all space.

The modern theory differs from the older ones, however, in this important respect: that whereas Franklin thought of each particle of the electrical fluid as acting at a distance, repelling every other particle, and thus explained electrical action, the modern theory supposes no such repulsive force. The particles of the electric fluid are not supposed to repel each other any more than particles of water do. But all actions are explained by taking account of the strains in the medium surrounding the charged bodies. For the electric fluid, while pervading all bodies, is not equally free to flow in all. In some, according to this view, the particles of electricity are not free to move, but if forced aside spring back to their original position as soon as the straining force is removed, just as shot would if imbedded in a mass of india rubber. Such bodies are insulators. In others the particles of electricity can be moved from one place to another, just as shot can be moved about in a mass of tar or molasses; a certain amount of resistance is experienced, but when the force is removed there is no tendency for the particles to spring back to their original places. Such bodies are conductors; and one offering great resistance to the electric displacement is a poor conductor, while one offering but little resistance is a good conductor. It is the elastic force with which the displacement of the electricity in insulators is opposed which gives rise to the attractions and repulsions of electrified bodies in insulating media.

One illustration may be taken to make this clear. Let A and B (Fig. 1) be two conductors joined by a wire in which is an electrical machine of some sort or a battery. The action is now regarded as follows: The electrical machine is a pump for electricity, drawing it out of B, let us suppose, and forcing it into A along the wire; but since the electric fluid is incompressible the amount contained in the body A cannot be changed, so when electricity is forced into it along the wire an equal quantity is displaced outward all over its surface. This causes a forcing outward of the electricity in the insulating medium surrounding the body A, and in like manner there must be an inward displacement over the body B. If lines are drawn so that each part of a line is in the direction of the electric displacement at that point then these lines must all start from A and terminate in B, because the fluid being incompressible the pump has, in forcing some of it out of B and into A along the wire, caused a displacement in the surrounding medium from A back toward B. If we think of any closed surface surrounding A, such as $C\,C$, the quantity of electricity displaced outward across that surface is exactly equal to the quantity forced into it along the wire, the total quantity within the surface remaining unchanged. Now along all these lines of displacement in the insulating medium the electricity is subject to the elastic force of the medium urging each particle back to its original position, just as shot imbedded in india rubber when displaced experience a force urging them back. This elasticity of the medium causes an increased pressure upon the electricity in A and a diminution of the pressure

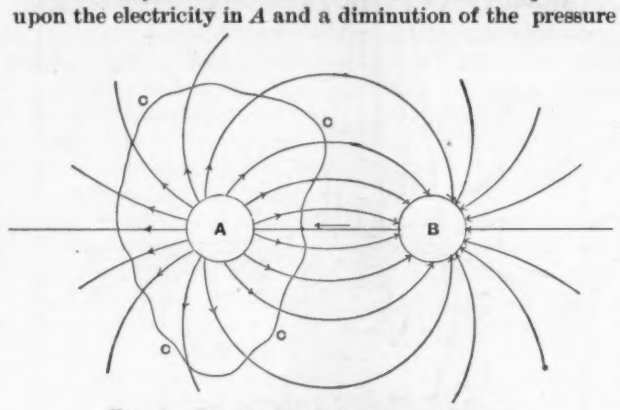


Fig. 1.—Diagram of Lines of Force.

in B, so that as soon as A and B are connected by a wire along which the electricity can freely flow it will rush back from A to B until the pressure is the same in each, and at the same time the displaced electricity in the insulating medium springs back to its original condition and the strain is relieved. Looked at from this point of view the discharge of an electrified body is seen to be due to the forcing of electricity out of the body by the pressure of the displaced electricity in the surrounding medium, and not to any inherent repulsion of one particle of electricity for another. Thus in case of a Leyden jar the electrical strain in the glass between the two coatings, and to some extent in the air around it, is the cause of the discharge, since this strain cannot be relieved without forcing some electricity from one coating around to the other.

It appears then that the characteristic distinction between the older and modern theories of electricity is the recognition by the latter of the fundamental importance of the dielectric or insulating media. This great step forward was made by Faraday.

As soon as it is clearly perceived that electrical disturbances are communicated from one point to another by means of the intervening dielectric, the question at once arises: are these disturbances communicated instantly or are they propagated with a certain finite velocity? Within the past few years the experiments of Hertz have definitely answered this question, and there is now no doubt but that electric disturbances, like sound and light, advance with a certain definite velocity, which depends on the medium through which they are communicated.

Maxwell, a number of years previously, had given reasons for believing that electromagnetic disturbances were propagated with the same velocity as light, and it is interesting to notice that the results obtained by Hertz agree with that conclusion.

KINDS OF ELECTRIC DISTURBANCES.

There are two kinds of electric disturbance that can be thought of: one where there is no magnetic effect

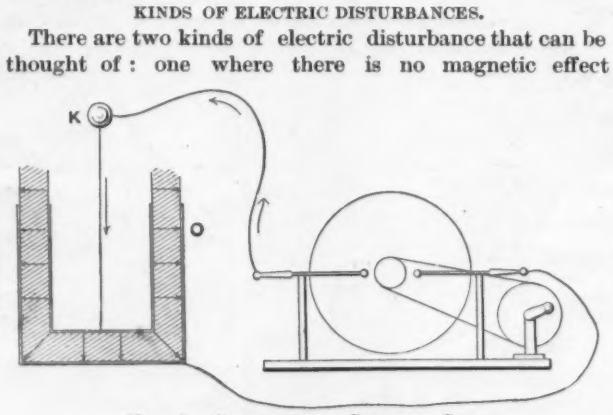


Fig. 2.—Charging a Leyden Jar.

and one where there is an electric current with its well-known magnetic actions. In reality, however, we are only concerned with the latter case, for the only way in which an electric disturbance could be produced without magnetic effect would be by suddenly creating or destroying some electricity at some point in space; but this cannot be done, for one of the fundamental points established by experiment is that equal quantities of positive and negative electricity are always developed; that is, electricity remains unchanged in amount and an excess at one point always implies a deficiency at some other point. If we had the power, however, to suddenly create a charge of electricity on a conductor it is probable that the disturbance, which would be an outward displacement of all the rest of the electricity, would be accomplished instantly, if even at the greatest distance and without requiring any finite time. This would result from the fact that the electric substance seems to be incompressible, and hence a crowding of more electricity in at any point would mean the outward displacement of all the rest at the same time. But this case has only a theoretical interest as it never arises in practice. In all actual electrifications, whether it be in the currents flowing in the circuits of a dynamo or in the discharges of an electrical machine, we are simply setting up currents and whirls in the vast ocean of electricity which surrounds and pervades us. In the Holtz machine the sparks which leap across between the electrodes simply mark the passage of a small amount of electricity which is being pumped around and around by the action of the machine, and in the dynamo we may think of the circuit as filled with electricity which is not being generated but simply made to flow around by the action of the machine. The circuit is just as truly full of electricity when the machine is not in action as when it is running, the sole function of the machine being to circulate the electricity.

It is believed that every kind of electrical disturbance that can be imagined is of this nature, that we always have to do with closed currents, and that there is no such thing as compressing more electricity into a space or exhausting it from one, but the most we can do is to set up eddies and currents, moving it from one place to another. Even such a case as the charge of a Leyden jar is to be regarded in this way. The following diagram (Fig. 2) will make this clear. The inner coating with its knob K is represented as connected with one pole of the electrical machine, while the outer coating O is connected with the other pole. When the machine is set in motion the circulation of the electricity is represented by the arrows, just as much flowing out of the outer coating as flows into the inner, and the same amount also is displaced outward in the insulating medium between the two coatings (neglecting the small displacement in air between the knob and outer coating). So that whether we note the flow across a section of the wire connected with the knob, or of the wire joined to the outer coating, or whether we observe the outward displacement across any surface in the insulating medium and surrounding the inner coating, the quantity of electricity passing each will be the same in the same time. Of course this can't go on long, for soon the strain in the insulating medium becomes so great that if we go further in charging the electricity bursts through and the jar is discharged. But so long as the action is going on there is a continuous current of electricity in the wires and in the insulating medium between the coatings. The peculiarity of this case is that in part of the circuit, the dielectric, the electricity is urged back to its original position by the elastic force of the medium, so that when the two coatings are connected there is discharge; while in case of the two poles of the electrical machine being connected simply by a conducting wire there is no such reacting force, and when the machine stops the current merely stops, with no tendency to a back rush.

All electrical disturbances, then, which we can produce are of the nature of closed currents, if we take account, as we must, of the displacements in the insulating media; and all currents produce magnetic effects and induce currents in neighboring conductors whenever their strengths vary.

TWO KINDS OF ELECTRICAL ENERGY.

One way in which electrical energy may be stored up in the medium is illustrated in case of the charged Leyden jar, and the energy of the charge exists as a strain in the insulating medium, and is analogous to the energy of a coiled spring. There is another most important mode in which electrical energy can exist in the medium, and that is as the energy of a magnetic field. No energy has to be expended to keep up a magnetic field. A horseshoe magnet may retain its magnetism for years, and is certainly not expending energy all the time; but to make a magnet requires a certain expenditure of energy which depends on the number of lines of force set up and on the strength of the magnetizing current. While a current is flowing steadily around an electromagnet it is expending energy, but that energy is merely being dissipated as heat in the conductor; there is no storing up of energy in the medium going on; but when we try to stop the current and make the magnet lose its magnetism, there is a sudden strong rush of electricity, greatly increasing the current. This is called the extra current, or current of self-induction; but it is simply the energy which was stored up as the energy of the magnetic field, which is thus suddenly returned to us as an increase of current. In the same way, on starting a current in an electromagnet it may be some seconds, in case of a large magnet, before the current reaches its full strength. The reason is obvious: the energy supplied by the battery is being partly expended in setting up this magnetic field, and the current cannot reach its steady state until the magnetism is fully established.

It is believed that this energy exists in the medium in some way as energy of motion or rotation, the axis of the rotating particles being in the direction of the lines of force.

There is no doubt but that there is a rotation of some sort going on in a magnetic field. Faraday's experiments on the rotation of the plane of polarization of a beam of light in a magnetic field admit of no other explanation that we can conceive of. It will be remembered that Faraday placed a block of dense glass in a strong magnetic field, and then sent a beam of plane polarized light through it in the same direction as the lines of force. The plane of polarization was observed to be rotated a certain amount. But why could not this effect be produced simply by a static strain of the glass of some sort, for it is

well known that a piece of quartz will have a similar effect on a beam of polarized light sent along its axis? The difference in the two cases lies in this, that if the beam of light after traversing the quartz is reflected back again it will come out just as it entered, the twist being taken out of it, so to speak; while if the light is sent back through the block of glass in the magnetic field it will be further rotated, the rotation always being in the same direction and irrespective of whether the beam is sent *with* the lines of force or *against* them. This is what renders this case so remarkable, and can only be explained by supposing a rotation of some sort about the lines of force in the medium. These two ways in which the medium may possess energy, the energy of electric strain which the medium may possess when the electricity is at rest and the energy of the magnetic field which can only exist when electricity is in motion, evidently correspond respectively to the potential energy of a coiled spring and the kinetic energy of a rotating wheel, one the energy due to stresses, and the other the energy due to motion.

THE NATURE OF AN ELECTROMAGNETIC WAVE.

It has already been noticed that there is experimental proof that the inducing effect of an electric disturbance is propagated with a velocity which, as near as can be determined, is the same as the velocity of light. But it is important to go behind this fact to inquire in what way this disturbance exists in the medium, and what are the elements that determine its velocity. Let us first examine somewhat closely what takes place when a current is induced in a coil by the starting or stopping of a current in an adjoining coil. Let A and B (Fig. 3) represent two parallel coils of wire and suppose a current is set up in A, then the lines of magnetic force will be somewhat as represented in the diagram, and the number of lines passing through the coil B together with the resistance of the coil B determines the amount of the induced current in B. This is the state of things as we ordinarily think of it, and is true enough after the induced current has died out and everything has come to a steady state; but when the current *begins* to flow in A the lines of force or magnetic whirls in the medium are first set up close around the coil A and spread outwards till they come to their final state, more and more being sent out from the coil till the field is fully established. Now the effect upon the coil B is produced in some way by the medium at the point where it is placed, as we have abandoned the idea of the coil A acting at a distance upon the coil B. The induced current is then set up in B by the action of the magnetic whirls in the medium cutting across the coil B as they spread out from the coil A. Of course all these whirls that finally go through B must cut across that coil, and since each causes a certain amount of inducing action the total induced current must depend on the number of lines of force that finally thread through the coil B.

Now an induced current always opposes the change in the magnetic field which brings it about. In the case under consideration the induced current is in such a direction as to oppose the cutting across the coil by the lines of force, and it is only when the induced current has died out, owing to the resistance of the coil B, that the lines of force come to their final state. It is instructive to think of what would happen if B were a perfect conductor, that is, had absolutely no resistance; in that case an induced current would be set up just strong enough to completely neutralize the effect of A within the coil B; that is to say, no lines of force would get through the coil B, and this induced current in B would continue to flow until the current in A was stopped, when the inducing action would be just sufficient to stop the current in B. In ordinary conductors the induced current soon dies out, and so they do not permanently change the direction of the lines of force, but simply delay them in cutting through the coil, and the smaller the resistance of the coil B the greater the action will be in retarding the lines of force as they cut across the coil. But now suppose B is not a conductor at all, but an insulator, just like any other part of the surrounding medium: the inducing action due to the magnetic whirls cutting across B is just the same as if it were a conductor; the difference is that in case of the insulator the electricity cannot flow, but can merely be displaced a little, and springs back as soon as the displacing force is removed. This action must, therefore, go on in every part of the medium through which lines of force pass, or, in other words, in which magnetic whirls are set up. On starting the current, as the magnetic lines of force spread out in the medium, or as the magnetic rotation is communicated to more and more distant parts of the dielectric, at every point the starting of the magnetic rotation produces a displacement of the electricity, and this elastic resistance to displacement enables the motion to be communicated to more distant parts. The following analogy will make this clear: Let A, B and C (Fig. 4) be three wheels geared together, and capable of rotating without friction. A and C are to represent two magnetic whirls, while B is a particle of electricity held in position by the springs on each side, which represent the elastic action of the insulating medium in urging the electricity back to its position when displaced. It requires energy to set up a magnetic field, as we have already seen. The energy is that of motion, and the analogy is to the energy of a rotating wheel. The wheels A and C at least must therefore be thought of as having a certain inertia, and when set in rotation their energy of motion represents the energy of the magnetic whirls.

Starting with the system at rest, suppose A to be set in rotation, it is easy to see that the inertia of C will cause the rotation of A to displace B to one side; if the rotation of A is in the direction of the arrow, B will be displaced downwards; but the elastic force of the medium resists the displacement of B, and as the motion is gradually given up to C, B will move back and will come to its original position as soon as C is turning as rapidly as A. If the springs holding B in place were very stiff, so that a great force was required to displace B even slightly, the motion would be communicated rapidly from A to C, and if the springs were very weak the motion would be given up much more slowly. We may think of a long row of such gear wheels, every other one being held in place by springs, and it is plain that the length of time which it takes to

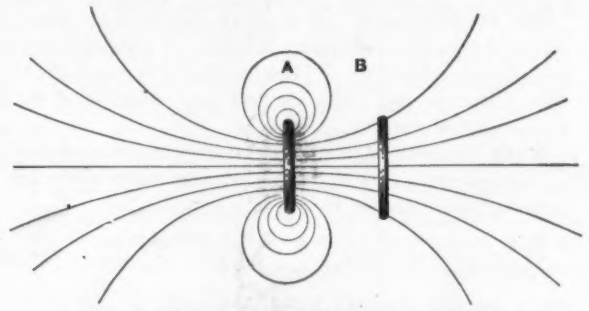


FIG. 3.—LINES OF FORCE FROM A CIRCUIT.

communicate a disturbance from A to the last one will depend on the stiffness of the springs and the inertia of the wheels. The stiffer the springs are the greater will be the velocity of propagation of the disturbance, and the greater the inertia of the wheels the less will be that velocity.

The analogy also illustrates the case of induction, for suppose B, instead of being held in position by springs, could be moved about in any way without any tendency to come back; suppose, for example, it were floated in a viscous liquid like molasses. Then, on turning A, B would immediately slip aside, and another would come in in its place and slip through, and so on, until gradually, as their motion is resisted somewhat by the liquid in which they move, the rotation would be communicated to C, and the B particles would merely turn round without moving aside. Plainly, the moving aside of the particles represents the induced current, which is gradually brought to rest by the resistance of the conductor, and only when the induced current has entirely died out is the full magnetic rotation communicated to the medium beyond.

The above analogy is useful in enabling us to form a somewhat clear conception of how the starting of a magnetic whirl at any point in the medium brings about an electric displacement and that the greater the resistance to the displacement the greater the velocity with which the disturbance is propagated.

HOW THE VELOCITY OF THE WAVE DEPENDS ON THE PROPERTIES OF THE MEDIUM.

The velocity of a wave is always determined by the properties of the medium in which it moves. Newton showed that in such a case as a sound wave the velocity is $v = \sqrt{\frac{e}{d}}$, where e is the elasticity of the medium and d is its density. In case of electromagnetic waves an exactly similar expression holds, except that instead of ordinary

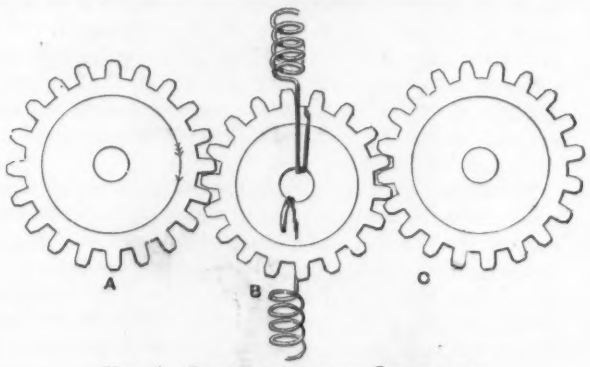


FIG. 4.—ILLUSTRATION OF INDUCTION.

elasticity we must put the elastic resistance which the medium offers to electric displacements, and instead of density we must put the effective inertia of the magnetic whirls.

Now the specific inductive capacity of a dielectric is a property which bears a direct relation to the resistance which the medium offers to electric displacement. This is readily seen in that the capacity of a Leyden jar is proportional to the specific inductive capacity of the dielectric. But the capacity of a Leyden jar is evidently increased by diminishing the elastic resistance to displacement, for the less this resistance the greater the quantity of electricity that can be forced into a jar by a given difference in pressure or potential between the two coatings. It may be shown thus that the specific inductive capacity of a medium is inversely proportional to its electrical elasticity, and therefore the greater the specific inductive capacity of the medium the less will be the velocity of the electromagnetic wave, other things being equal.

In a rotating wheel the energy of rotation is determined by the inertia of the wheel and the velocity of rotation. the inertia of the wheel belongs to it and cannot be changed, while the velocity of rotation may be made anything that is desired. In the same way, in determining the energy of a portion of a magnetic field there is part that depends on the magnetizing current and part that depends only on the medium. It is this latter part, the magnetic permeability of the medium, as it is called, which corresponds to the inertia of the wheel, and it is this quantity which corresponds to density in the expression for the velocity of a wave given above. Thus the greater the magnetic permeability of the medium the less will be the velocity of the electric disturbance.

These two results are embodied in the following expression which was established by Maxwell:

$$v = \sqrt{\frac{1}{K\ \mu}}$$

where v is the velocity of the wave, K is the specific inductive capacity of the medium and μ is its magnetic permeability, all measured in the same system of units.

The value of this quantity has been carefully determined for the case of vacuum where the insulating medium is the luminiferous ether and is found to be the same as the velocity of light, 186,330 miles per second, as nearly as experiment can determine. This is one of many remarkable facts connecting light and electricity.

WHEN ARE ELECTROMAGNETIC WAVES SENT OUT?

We have examined somewhat closely, in studying the nature of a wave of electrical disturbance, the wave sent out on starting a current, and evidently in a very short time the magnetic field, except at enormous distances from the current, comes to a steady state and there is no longer anything like a wave. Of course, if we go far enough from the source of the disturbance the wave will be found there advancing with the velocity of light into the regions of space, but the magnetic effect of all disturbances such as we can produce must be vanishingly small, at a distance of a few thousand miles at most. If now the magnetizing current is suddenly stopped it is usual to think and speak of the magnetic field as being wholly done away, the magnetic whirls coming to rest and giving back their energy to the current, thus producing the extra current or current of self-induction. But this is not strictly true. Only a part of the energy that was expended in setting up the magnetic field is returned to the circuit in the self-induced current; the rest goes into space as a wave of electrical disturbance. The energy thus given off is sometimes said to be radiated, as a wave of energy is sent off from the electrical system just as the energy is radiated or sent off in waves from a hot body.

It is to be noticed, however, that there is no radiation or giving out of electrical waves from a steady current. The magnetic field around such a current remains constant, and energy is neither given up to it nor by it. It is only when changes occur in the magnetic field that waves are set up. When a current is regularly reversed, as in the case of ordinary alternating currents, an electrical wave is sent out by each complete change, so that if the current is reversed 100 times a second, thus giving 50 complete alternations, there will be 50 waves a second sent out from the system, and since the velocity of propagation of the waves is 186,330 miles per second, the first will have gone that distance by the time the fiftieth is sent out; the waves will therefore each have a wave length of 3,726.6 miles. It is an interesting question whether the amount of energy thus given off is appreciable or not, for if a notable part of the energy of an alternating system is thus radiated by waves out into space it is an important point to be taken into consideration.

The amount of energy that is thus lost depends partly on the wave length and in part on the suddenness with which the current is started and stopped. The more abruptly a current is started and stopped the greater the amount of energy radiated. In all commercial cases of alternating currents the amount of energy radiated must be inappreciably small, since the wave length of the disturbance is immensely great compared with the distance at which the magnetic field set up has any appreciable strength, and the reversal is not sudden, but very gradual, as the current rises to a positive maximum and then, sinking to zero, passes to a negative maximum without any sudden or sharp changes in intensity.

When, however, the wave length is short compared with the distance to which the sensible magnetic field extends, a very considerable proportion of the energy expended in setting up the magnetic field will never be returned to the circuit, but will pass out into space in electromagnetic waves. In order then that a series of energetic electromagnetic waves may be set up, it is necessary to have an alternating current of considerable intensity in which the reversals shall take place with such rapidity as to give rise to waves a few feet long. At first sight it appears impossible to satisfy these conditions, as the velocity of these waves is so great that a current alternating 186,330 times per second could send out waves a mile long, and to get waves even 10 feet long would require the alternations to be 528 times as frequent, or nearly 100,000,000 per second. Obviously no commutator or reversing contrivance could be expected to give such a number of reversals, and for some time it seemed almost as though the actual setting up of such waves and measurement of their wave lengths must be abandoned as hopeless. But within three years Hertz has shown that even these rapid alternations may be obtained and the waves experimented with.

(To be continued.)

On the Electro-Dynamics of Stationary Bodies.*

BY H. HERTZ.

Conservation of Energy.—Let us denote by S the electromagnetic energy in a given volume τ, an element of whose surface is represented by dw. From (10) and (11), by multiplying the equations respectively by L, M, N, X, Y, Z, adding, and integrating throughout the volume considered, we deduce, in the same manner as in equation (4), the result.

$$4\pi A \frac{dS}{dt} = -4\pi A \int (uX + vY + wZ)\, d\tau + \int \begin{vmatrix} \cos(n,x) & \cos(n,y) & \cos(n,z) \\ X & Y & Z \\ L & M & N \end{vmatrix} dw \qquad (23)$$

and if the volume τ includes a complete electromagnetic system, so that the forces disappear at the surface, this equation reduces to

$$\frac{dS}{dt} = -\int (uX + vY + wZ)\, d\tau \qquad (24)$$

This equation leads us to the conclusion that each unit of volume is a source of energy, and producing it at the rate denoted by $(uX + vY + wZ)$. Experience tells us in what form this energy shows itself in particular cases. In the interior of good conductors the quantity of energy generated per unit volume in a unit of time is, according to both theory and practice, given by either of the equivalent expressions:

$$\lambda(X^2 + Y^2 + Z^2) = \frac{1}{\lambda}(u^2 + v^2 + w^2)$$

where $\frac{1}{\lambda}$ is the specific resistance, X, Y, Z are the components of the electromotive force, and u, v and w the components of the electric current. These expressions are in perfect accordance with (24), since for such conductors we have $u = \lambda X$, $v = \lambda Y$, $w = \lambda Z$.

Again at the bounding surface of isotropic homogeneous bodies the quantity of energy produced in the separating layer per unit volume, per unit of time, is given by the expression

$$uX' + vY' + wZ'.$$

An integration extended from one side to the other of the separating layer shows that the rate of increase of energy per unit of separating surface is equal to

$$(u\cos(n,x) + v\cos(n,y) + w\cos(n,z))\,\varphi_{12}$$

or proportional to the current of electricity across the surface. Experience shows that a similar expression holds true in practice. Its value may be positive or negative, and, according to circumstances an augmentation or diminution of energy may be denoted by it. If this energy takes the form of heat it corresponds with the Pelter effect, and we call the electromotive force acting a thermo-electric one. If we have to consider the chemical energy as well as the heat energy, we call the electromotive force a chemical one.

Finally, let us consider a limited portion of the system, and calculate the rate at which the total energy is increased. This rate is given by the expression

$$\frac{dS}{dt} + \int (uX + vY + wZ)\, d\tau$$

since it must exceed the rate of increase of electromagnetic energy by the quantity denoting the rate at which energy is being dissipated. By reference to (23) it is thus apparent that the variation of the energy accumulated within any space can be exactly calculated by supposing that the energy travels across the bounding surface in such a way that the energy current per unit of area of the bounding surface is equal to

$$\frac{1}{4\pi A} \begin{vmatrix} \cos(n,x) & \cos(n,y) & \cos(n,z) \\ X & Y & Z \\ L & M & N \end{vmatrix} \qquad (25)$$

Investigation of this expression shows that the energy current thus defined flows at right angles to the direction of both the electric and magnetic forces, and that its value is equal to the product of the two forces, multiplied by the sine of the angle between them and divided by $4\pi A$.

In discussing this hypothesis of an energy current, it must be noticed that the way in which the integral has been split up is quite arbitrary, and that the results to which it leads are not always probable. For example, when a magnet is placed near an electrified body, the energy in the neighboring space must, according to this view, be continually in motion in closed cycles. It seems to me that, in the actual state of our knowledge, we must accept with caution the idea of the localization of energy, and its motion from one point to another. No analogous principles have as yet been introduced into the study of rational mechanics.

PART B.

EXPLANATION OF THE PHENOMENA BY MEANS OF THE FUNDAMENTAL EQUATIONS.

We shall divide the phenomena to which our equations refer into three distinct groups—static, stationary or steady, and dynamic. A phenomenon can only be considered static or steady when the electric and magnetic forces do not change with time; and it is thus necessary, in these two cases, for the first members of equations (10) and (11) to disappear. For static phenomena it is, in addition, necessary that no variation shall occur in any of the quantities defining the state, and thus no transformation of energy can arise. For this to be the case, the values of u, v, and w must be zero.

Static Phenomena.

On substituting zero for u, v, and w, in (11), and also for the left hand members of each of the equations (10) and (11), we notice that the equations divide themselves into two distinct groups; the first of which (10) refers to electrostatics, and the other (11) to magnetostatics.

Electrostatics.—For good conductors the forces X, Y, Z must be zero, since otherwise currents would be produced. For bad conductors equations (10) reduce to

$$\frac{dZ}{dy} - \frac{dY}{dz} = \frac{dX}{dz} - \frac{dZ}{dx} = \frac{dY}{dx} - \frac{dX}{dy} = 0,$$

and it follows that a potential φ exists, for which

$$X = -\frac{d\varphi}{dx} \qquad Y = -\frac{d\varphi}{dy} \qquad Z = -\frac{d\varphi}{dz}. \qquad (26)$$

The function φ is, in general, continuous, since the forces are generally finite. It must be constant throughout a good conductor; and the tangential component of the force must be the same on the two sides of a surface separating two media.

If the quantity of "true" electricity in a unit volume be ρ_p we see from (17) and (8), and the expressions for X, Y and Z given above, that

$$\frac{d}{dx}\left(\varepsilon\frac{d\varphi}{dx}\right) + \frac{d}{dy}\left(\varepsilon\frac{d\varphi}{dy}\right) + \frac{d}{dz}\left(\varepsilon\frac{d\varphi}{dz}\right) = -4\pi\rho_p;$$

since in (8) we may put $\varepsilon_{11} = \varepsilon_{22} = \varepsilon_{33} = \varepsilon$, and the other coefficients are zero.

For free ether we may put $\varepsilon = 1$, and the volume density of "free" electricity being denoted by ρ we obtain

$$\Delta\varphi = \frac{d^2\varphi}{dx^2} + \frac{d^2\varphi}{dy^2} + \frac{d^2\varphi}{dz^2} = -4\pi\rho. \qquad (27)$$

This equation reduces to $\Delta\varphi = 0$ for all parts of space which are uncharged. The function φ, which satisfies these equations, is

$$\varphi = \int \frac{\rho}{r}\, d\tau \qquad (28)$$

where r is the distance of the point considered from the volume elements $d\tau$, which is charged to a density ρ; and this is the well-known expression for the potential at a point due to surrounding charged bodies. Coulomb's law of electric attraction and repulsion follows at once, since the force in the direction r is $-\frac{d\varphi}{dr}$, and this by differentiation is seen to be inversely proportional to r^2.

The expression given in (12) for the electric energy—

$$\frac{1}{8\pi}\int (X X_p + Y Y_p + Z Z_p)\, d\tau$$

can by suitable transformations be reduced to—

$$\frac{1}{2}\int\int \frac{\rho_p \rho}{r}\, d\tau\, d\tau$$

Magnetostatics.—All the remarks made in the preceding section about the electric forces can be repeated with very slight modification with reference to the magnetic forces. There are, however, certain points of difference.

1. The distinction of bodies into conductors and non-conductors does not exist.

2. With the exception of bodies exhibiting the phenomena of permanent magnetism the "true" magnetic density is everywhere zero.

3. Although the dielectric constant ε of all known bodies is greater than 1, the magnetic constant μ of a great number of bodies is, on the contrary, less than 1. Bodies are called paramagnetic or diamagnetic according as the value of μ for them is greater or less than 1. The surface density of "free" magnetism on a bounding surface is proportional to $(1 - \mu)$, and is thus of opposite sign for the two classes of bodies.

The science of magnetostatics acquires a special significance, because iron and steel, the most important substances dealt with, only obey the theory very roughly. The polarization of the particles is in part independent of the acting forces, and is not determined by a single directed quantity. The relations are, moreover, no longer linear, and thus these substances must be regarded as outside the scope of the present theory. We may, however, for theoretical purposes, replace them by two imaginary bodies; perfectly soft iron and perfectly hard steel. These are defined as bodies obeying the equations, and having a coefficient μ, which is very large indeed for soft iron, and equal to unity for hard steel.

Phenomena of the Steady State.

In bad conductors, as soon as the steady state is established, the same conditions hold as for static phenomena. For homogeneous conducting bodies, equations (10), (11) and (9) take the form

$$\frac{dZ}{dy} = \frac{dY}{dz}, \qquad \frac{dX}{dz} = \frac{dZ}{dx}, \qquad \frac{dY}{dx} = \frac{dX}{dy} \qquad (29)$$

and

$$\left.\begin{aligned} \frac{dM}{dz} - \frac{dN}{dy} &= 4\pi A u \\ \frac{dN}{dx} - \frac{dL}{dz} &= 4\pi A v \\ \frac{dL}{dy} - \frac{dM}{dx} &= 4\pi A w \end{aligned}\right\} \qquad (30)$$

$$u = \lambda(X - X'), \quad v = \lambda(Y - Y'), \quad w = \lambda(Z - Z'). \qquad (31)$$

From (30) we obtain by differentiation

$$\frac{du}{dx} + \frac{dv}{dy} + \frac{dw}{dz} = 0 \qquad (32)$$

And the modification of this at every separating surface can be shown to be

$$(u_2 - u_1)\cos(n,x) + (v_2 - v_1)\cos(n,y) + w_2 - w_1)\cos(n,z) = 0 \qquad (33)$$

The equations (29), (31), (32) and (33) determine a system without reference to the magnetic forces, which may therefore be left out of account. When the components u, v, w of the current are found, it is easy, by means of equations (30), to obtain the magnetic forces exerted by the current.

Distribution of Steady Currents.—From (29) we conclude that the forces X, Y, Z are the differential coefficients, with the sign changed, of a potential function φ. This is true even within a good conductor, and it follows from this, and from (31) and (32), that at all points we have

$$\frac{d}{dx}\left(\lambda\frac{d\varphi}{dx}\right) + \frac{d}{dy}\left(\lambda\frac{d\varphi}{dy}\right) + \frac{d}{dz}\left(\lambda\frac{d\varphi}{dz}\right) = -\left[\frac{d}{dx}(\lambda X') + \frac{d}{dy}(\lambda Y') + \frac{d}{dz}(\lambda Z')\right] \qquad (34)$$

At the surface separating two media this equation takes the form

$$\lambda_2\left(\frac{d\varphi}{dn}\right)_2 - \lambda_1\left(\frac{d\varphi}{dn}\right)_1 = -\left[(\lambda_2 X'_2 - \lambda X'_1)\cos(n,x) + (\lambda_2 Y'_2 - \lambda_1 Y'_1)\cos(n,y) + (\lambda_2 Z'_2 - \lambda_1 Z'_1)\cos(n,z)\right] \qquad (35)$$

If one of the media is conducting, we have

$$\left(\frac{d\varphi}{dn}\right)_1 = 0 \qquad X'_1 = Y'_1 = Z'_1 = 0$$

and if. under these circumstances, we integrate φ along the normal n, we have

$$\varphi_1 - \varphi_2 = \int [X'\cos(n,x) + Y'\cos(n,y) + Z'\cos(n,z)]\, d\,n. \qquad (36)$$
$$= \varphi_{12}$$

If the integral is taken across an infinitely thin bounding layer between two media, we may obtain a finite value for the integral, even though the forces X', Y', Z' are infinite throughout the layer, and in this case φ_{12} may be called the electromotive force of contact between the two media. Equations (34) and (35) show that $\Delta\varphi = 0$ within a good conductor, $\lambda_1\left(\frac{d\varphi}{dn}\right)_1 = \lambda_2\left(\frac{d\varphi}{dn}\right)_2$ at a surface separating good conductors, $\frac{d}{d}\frac{\varphi}{n} = 0$ at a surface separating a good conductor from a bad one.

These equations refer to conductors in three dimensions. When linear conductors are considered the modified equations are very simple to use, and by employing them we may readily deduce the definition of resistance, the law of Ohm and Kirchhoff's laws.

* Continued from the ELECTRICAL WORLD, Oct. 25, 1890.

Statistics of Submarine Telegraphs.

The international bureau of telegraph administrations has made an interesting report upon the extent to which submarine telegraphy has grown. The submarine system of the world, says the report, embodies 120,079 nautical miles of cable, of which various government administrations own and operate 12,524 miles, while the remainder is in the hands of private companies. The total cost of these cables is estimated to be $200,000,000. The Eastern Telegraph Company, which owns the cable between England and India, operates 21,860 miles, with a far east extension of 12,958 miles more. Africa is completely surrounded by submarine cables, with an occasional branch to the coast, the last link having been finished to Cape Town only last year. To encircle the Dark Continent 17,000 miles of cable was required, and a dozen or more companies, backed and aided by the British, French, Spanish and Portuguese governments, participated in the work. The north Atlantic is spanned by eleven cables, all laid since 1870, and footing up an aggregate of over 30,000 miles between North America and Europe.

A Cable to Australia.

A telegram from Ottawa, Ont., says that Sir John Pender has informed Mr. Sandford Fleming that he hopes to visit Hong-Kong next year by way of Canada, traveling by the Canadian Pacific line, when he hopes to inspect that wonderful undertaking in which Mr. Fleming has played such a prominent part and at the same time discuss with him the best means of establishing closer telegraphic communication between Canada and the Australian colonies when the time is ripe for carrying out the work. The friends of the Eastern Telegraph Company have at last to recognize the absolute necessity for an alternative cable to Australia by way of Canada and the Pacific. In the same letter the chairman of the Eastern Company says: "If the various governments interested are determined to have a line across the Pacific, and are prepared to incur the requisite expenditures for the purpose, I am quite ready, as I have always told you, to co-operate in carrying out the work on fair and reasonable terms. In this way the object might be obtained more easily and economically than if the third parties were employed." Mr. Fleming says in his reply that the means taken to establish the new telegraphic communication is entirely secondary, provided that the new line be secured.

Electrical Distribution by Transformers from Central and Eccentric Stations.*

BY DR. J. A. FLEMING, M. A.

§ 14. *Switchboards and Regulators.*—The switchboard arrangements in this system are particularly well devised. A switchboard is generally set up for each dynamo and

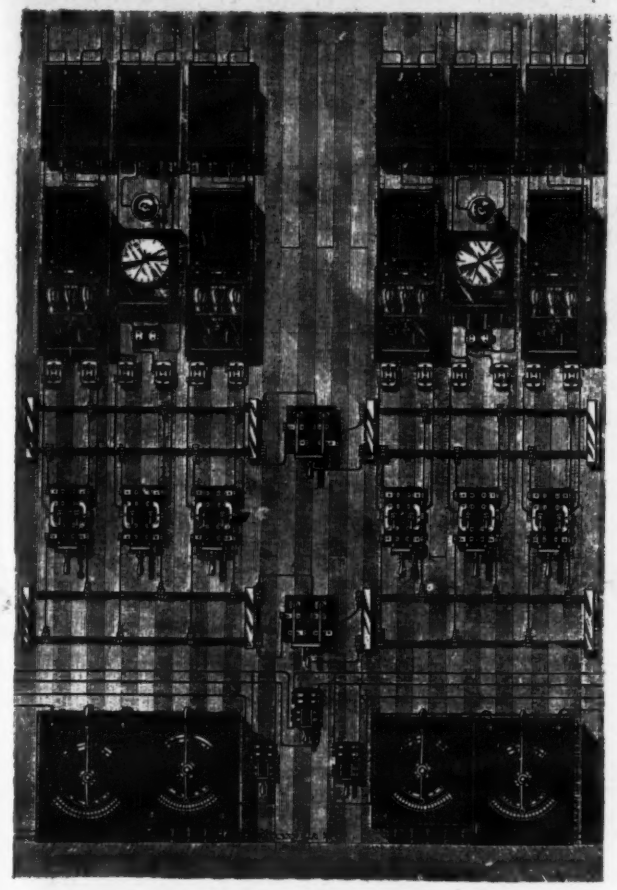


FIG. 40.—SWITCHBOARD.

for five or six feeders. The usual American practice is not to work the dynamos in parallel, although this is quite practicable, but to permit each dynamo to supply two or more feeding or primary circuits at full load, and then, as the load goes off, to group or gather together the feeders on to one or two dynamos in order to keep the working dynamos as far as possible fully loaded up. Fig. 40 shows a switchboard arrangement (not, however, the newest form) for two dynamos and four primary lines.

Commencing at the bottom of the switchboard we see four rheostats. The two small ones at the centre control the field circuits of the exciters. It is the usual practice to provide each station having more than one dynamo with duplicate exciters, each having a capacity sufficient to charge the fields of all the alternate dynamos. Only one exciter is in use at a time, the other standing idle as a reserve. It follows, therefore, that the governing of the electromotive force of all the alternators is effected by an introduction of resistance into the field circuit of this exciter.

The control of the electromotive force of each separate alternator is effected by the introduction of resistance into the field circuits of these machines by the rheostats on either side of the middle ones. The small changing switches

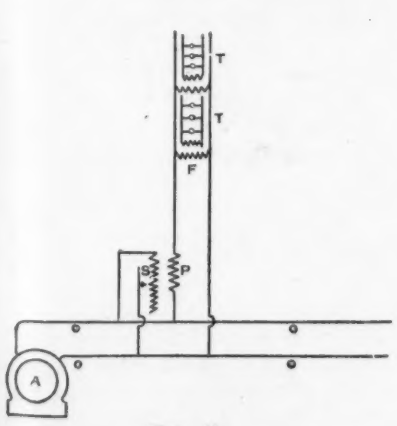


FIG. 41.

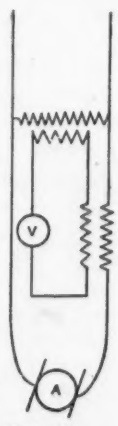


FIG. 42.

between the rheostats are for connecting either exciter with either dynamo at will, and for connecting the field circuits of both dynamos together. Over the rheostats are shown four sets of trunk wires, each consisting of two heavy parallel copper rods. Between each upper and lower set are three changing switches. The wires leading to the middle connection of the centre switch come from the No. 1 dynamo, whose current can be delivered to the upper or lower trunk wires at pleasure. The two outside switches of each triplet enable the primary wire attached to the centre connection of the switch to be put in connection with either trunk circuit at pleasure. Between the two sets of trunk wires are seen two multiple-arcing switches, which enable the dynamos to be run in parallel if desired, and a synchronizer or phase indicator is provided as described in connection with the Leghorn Central station (see § 9) to enable the dynamos to be put in parallel when in phase.

Over the trunk wires come a row of six safety catch-holders, each with double fuses and plug cut-outs. Over these safety fuses are four voltmeters, each with its attendant compensator above it. These voltmeters serve to measure the pressure at the far end of the line, and the compensator corrects the voltmeter reading for the fall in volts along the line. Between the voltmeters on the dynamo main comes the ampèremeter. At the top of the switchboard is a row of small transformers, which serve to reduce the pressure for the voltmeter. It is easily seen that a large variety of possible changes are readily effected with a switchboard of this kind, and that it enables one attendant to regulate a number of feeding or primary circuits. In larger central station switchboards the arrangement is somewhat different. For each feeding or primary main there is a separate panel, and, by an arrangement of plug switches, any one of the whole battery of dynamos can be worked on to this feeder. Also, by a throw-over switch in the centre of this board, this feeder can be instantly thrown over on to any other selected dynamo. Hence it becomes the easiest operation to group or collect or change over the feeders from one machine to the other; and American practice has seemed to indicate that this arrangement is, on the whole, easier to operate than working the dynamos in parallel.

When several feeders proceed from one dynamo, and on these supply lines different consumption exists than in each of the primaries, the fall in volts may require adjustment from time to time. To introduce resistance in the feeder would be a very crude device; the necessary independent adjustment of the volts at the far end of the feeder can be better obtained by a method due to Mr. G. Kapp. Let *O*, *O*, Fig. 41, be the omnibus bars from which the feeders start. The feeder *F* has in series with it one coil, *P*, of a transformer, the other coil of which is a shunt across the omnibus bars; by inserting more or less of the turns of the coil *S* into circuit by a shifting contact, a little auxiliary volts are put into the feeder by the inductive action of the coil, which is in shunt across the omnibus bars. This regulating device may be so designed as to add, or be capable of adding, 50 to 100 volts to the 1,000 or 2,000 volts already on the feeder; hence a movement of a lever enables the station engineer to adjust with great accuracy the volts at the far end of the feeder, and to do this for each feeder independently, even though all may be working off one dynamo. The arrangement employed for determining the volts at the far end of the feeder is essentially the same as the method already described in connection with the Ganz system. The voltmeter is in series with the secondary circuits of two transformers, one of which has its primary in series with the feeder circuit and the other of which has its primary as a shunt across the feeder. (See Fig. 42.) The electromotive forces of these two transformers are opposed to one another. Since the secondary electromotive force of the transformer in shunt is proportioned to the primary electromotive force, and since the secondary electromotive force of the transformer in series is proportional to the primary current strength, the difference between the two is proportional to $V - R\ C$, where V is the primary volt and C the primary current strength. As already explained, this difference is proportional to the pressure at the far end of the feeder, and by proper adjustment the voltmeter can be made to indicate this pressure, without any need for pressure wires run back to the station. In the Westinghouse system the necessary transformers for this purpose are put together into a box and called a compensator (see Fig. 43); all that has to be done is to connect the voltmeter to the compensator.

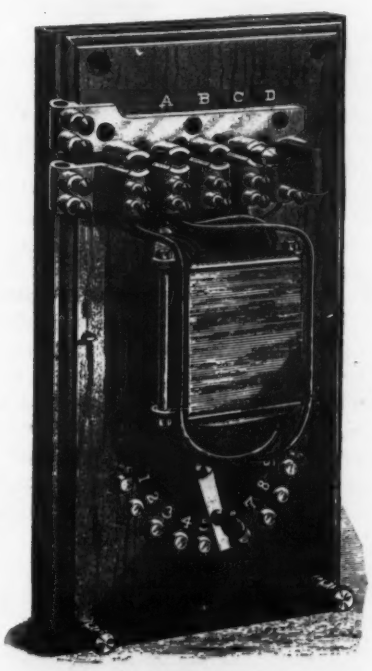


FIG. 43.—COMPENSATOR.

In addition to the regulation of pressure which is carried on at the station, it is necessary at theatres and in houses to be able to adjust the working electromotive force on the lamp circuits. There are two neat devices used by the Westinghouse Company for this purpose, called stage and house regulators. The stage regulator, intended

FIG. 44.—STAGE REGULATOR.

chiefly for the regulation of stage lights, is shown in Fig. 44. It consists of two connected coils of wire, with an iron core not quite so long as one bobbin sliding through both. One coil may be called the series and the other the shunt coil. The diagram below (Fig. 45) shows the mode of connection to the lamp circuit and transformer. When the iron core is pushed wholly within the shunt coil it bestows upon it such inductance that it blocks out all current through the shunt, and the lamps will be at their full brilliancy. On gradually drawing the iron core out of the shunt coil and into the series coil the inductance of the series coil is increased, and that of the other is diminished.

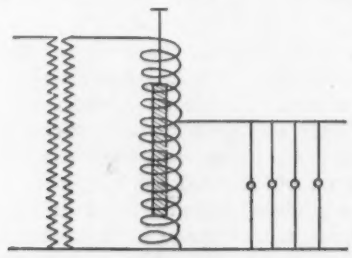


FIG. 45.

Hence the current through the lamps is diminished by both actions, and the lamps become less bright.

A somewhat similar arrangement is provided for a house regulator. Across the secondary circuit of the house transformer is a single coil (see Fig. 46), and the several sections of this coil are brought up to a revolving contact. By turning a handle more or less impedance can be inserted in the lamp circuit. The coil also acts as an auto-converter, and can be made to raise the lamp volts slightly above the volts at the terminals of the transformer. The coils of the regulator, which project as it were beyond the points *a b*, at which the transformer secondary circuit is joined in, have inductive electromotive force set up in them by the neighboring coils, which, being added to the actual secondary or impressed electromotive force, between *a b*, make it possible to have the volts on the lamps actually higher than the secondary terminal volts at the transformer.

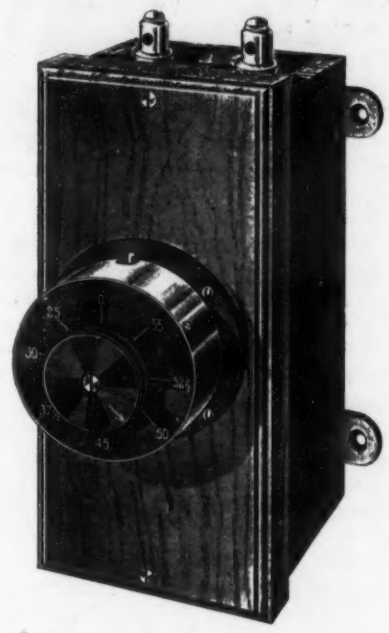


FIG. 46.—HOUSE REGULATOR.

(To be continued.)

*Continued from THE ELECTRICAL WORLD, Nov. 1, 1890.

The Electromagnet.*

BY PROF. SILVANUS P. THOMPSON, D. Sc., B. A. M. I. E. E.

SPECIAL DESIGNS.

In continuation of my lecture of last week I have to make a few remarks before entering upon the consideration of special forms of magnets which was to form the entire topic of to-night's lecture. I had not quite finished the experimental results which related to the performance of magnets under various conditions. I had already pointed out that where you require a magnet simply for holding on to its armature common sense (in the form of our simplest formula) dictated that the circuit of iron should be as short as was compatible with getting the required amount of winding upon it. That at once brings us to the question of the difference in performance of long magnets and short ones. Last week we treated that topic so far as this, that if you require your magnet to attract over any range across an air space you require a sufficient amount of exciting power in the circulation of electric current to force the magnetic lines across that resistance, and therefore you require length of core in order to get the required coil wound upon the magnetic circuit. But there is one other way in which the difference of behavior between long and short magnets—I am speaking of horseshoe shapes—comes into play. So far back as 1840, Ritchie found it was more difficult to magnetize steel magnets (using for that purpose electromagnets to stroke them with) if those electromagnets were short than if they were long. He was of course comparing magnets which had the same tractive power, that is to say, presumably had the same section of iron magnetized up to the same degree of magnetization. This difference between long and short cores is obviously to be explained on the same principle as the greater projecting power of the long-legged magnets. In order to force magnetism not only through an iron arch, but through whatever is beyond, and which has a lesser permeability for magnetism, whether it be an air gap or an arch of hard steel destined to retain some of its magnetism, you require magnetomotive force enough to drive the magnetism through that resisting medium; and, therefore, you must have turns of wire. That implies that you must have length of leg on which to wind those turns. Ritchie also found that the amount of magnetism remaining behind in the soft iron arch, after turning off the current at the first removal of the armature, was a little greater with long than with short magnets; and, indeed, that is what we should expect now, knowing the properties of iron, that long pieces, however soft, retain a little more—have a little more memory, as it were, of having been magnetized—than short pieces. Later on I shall have specially to draw your attention to the behavior of short pieces of iron which have no magnetic memory.

WINDING OF THE COPPER.

I now take up the question of winding the copper wire upon the electromagnet. How are we to determine beforehand the amount of wire required and the proper gauge of wire to employ?

The first stage of such a determination is already accomplished; we are already in possession of the formulæ for reckoning out the number of ampère-turns of excitation required in any given case. It remains to show how from this to calculate the amount of bobbin space, and the quantity of wire to fill it. Bear in mind that a current of 10 ampères (*i. e.*, as strong as that used for a big arc light) flowing once around the iron produces exactly the same effect magnetically as a current of one ampère flowing around ten times, or as a current of only one-hundredth part of an ampère flowing around a thousand times. In telegraphic work the currents ordinarily used in the lines are quite small, usually from five to twenty thousandths of an ampère; hence in such cases the wire that is wound on need only be a thin one, but it must have a great many turns. Because it is thin and has a great many turns, and is consequently a long wire, it will offer a considerable resistance. That is no advantage, but does not necessarily imply any greater waste of energy than if a thicker coil of fewer turns were used with a correspondingly larger current. Consider a very simple case. Suppose a bobbin is already filled with a certain number of turns of wire, say 100, of a size large enough to carry one ampère, without overheating. It will offer a certain resistance, it will waste a certain amount of the energy of the current, and it will have a certain magnetizing power. Now suppose this bobbin to be rewound with a wire of half the diameter; what will the result be? If the wire is half the diameter it will have one-quarter the sectional area, and the bobbin will hold four times as many turns (assuming insulating materials to occupy the same percentage of the available volume). The current which such a wire will carry will be one-fourth as great. The coil will offer sixteen times as much resistance, being four times as long and of one-fourth the cross-section of the other wire. But the waste of energy will be the same, being proportional to the resistance and to the square of the current; for $16 \times \frac{1}{16} = 1$. Consequently the heating effect will be the same. Also the magnetizing power will be the same, for though the current is one-fourth of its former value it flows around four times as many turns; the ampère-turns are the same as before. It therefore does not matter in the least to the magnetic behavior of the electromagnet whether it is wound with thick wire or thin wire, provided the thickness of the wire corresponds to the current it has to carry, so that the same number of watts of power are spent in heating it. For a coil wound on a bobbin of given volume the magnetizing power is the same for the same heat waste. But the heat waste increases in a greater ratio than the magnetizing power, if the current in a given coil is increased; for the heat is proportional to the square of the current, and the magnetizing power is simply proportional to the current. Hence it is the heating effect which in reality determines the winding of the wire. We must—assuming that the current will have a certain strength—allow enough volume to admit of our getting the requisite number of ampère turns without overheating. A good way is to assume a current of one ampère while one calculates out the coil. Having done this, the same volume holds good for any other gauge of wire appropriate to any other current. The terms "long coil" magnet and "short coil" magnet are appropriate for those electromagnets which have, respectively, many turns of thin wire and few turns of thick wire. These terms are preferableto "high resistance" and "low resistance," sometimes used to designate the two classes of windings; because, as I have just shown, the resistance of a coil has in itself nothing to do with its magnetizing power. Given the volume occupied by the copper, then for any current density (say, for example, a current density of 2,000 ampères per square inch of cross-section of the copper), the magnetizing power of the coil will be the same for all different gauges of wire. The specific conductivity of the copper itself is of importance; for the better the conductivity the less the heat waste per cubic inch of winding. High conductivity copper is therefore to be preferred in every case.

Now the heat which is thus generated by the current of electricity raises the temperature of the coil (and of the core), and it begins to emit heat from its surface. It may be taken as a sufficient approximation that a single square inch of surface, warmed one degree Fahr. above the surrounding air, will steadily emit heat at the rate of $\frac{1}{3\frac{1}{2}5}$ of a watt. Or, if there is provided only enough surface to get rid of a steady emission of heat at the rate of one watt* per square inch of surface, the temperature of that surface will rise to about 225 degrees Fahr. above the temperature of the surrounding air. This number is determined by the average emissivity of such substances as cotton, silk, varnish, and other materials of which the surfaces of coils are usually composed.

The resistance of the insulated copper wire on a bobbin may be approximately calculated by the following rule. If d is the diameter of the naked wire, in mils, and D is the diameter, in mils, of the wire when covered, then the resistance per cubic inch of the coil will be:

$$\text{Ohms per cubic inch} = \frac{960{,}700}{D^2 \times d^2}.$$

We are therefore able to construct a wire gauge and ampereage table which will enable us to calculate readily the degree to which a given coil will warm when traversed by a given current, or conversely what volume of coil will be needed to provide the requisite circulation of current without warming beyond any prescribed excess.

In the specifications for dynamo machines it is usual to lay down a condition that the coils shall not heat more than a certain number of degrees warmer than the air. With electromagnets it is a safe rule to say that no electromagnet ought ever to heat up to a temperature more than 100 degrees Fahr. above the surrounding air. In many cases it is quite safe to exceed this limit.

Accordingly, I here give a wire-gauge and ampereage table which we have been using for some time at the Finsbury Technical College. It was calculated out under my instructions by one of the demonstrators of the college, Mr. Eustace Thomas, to whom I am indebted for the great care bestowed upon the calculations.

TABLE X.—WIRE GAUGE AND AMPEREAGE TABLE.

Dimensions.					Permissible Ampèreage, Probable Heating, and Permissible Depth.											
					At 1,000 amps. to sq. inch.			At 2,000 amps. to sq. inch.			At 3,000 amps. to sq. inch.			At 4,000 amps. to sq. inch.		
S. W. G.	Diam. (inch.)	Section. (sq. inch bare.)	Turns to 1 linear inch. (covered.)	Turns per sq. inch. (covered.)	A	F	D	A	F	D	A	F	D	A	F	D
22	.028	.00062	23.81	624.0	.616	2.28	4.5	1.23	9.12	1.13	1.85	20.52	.50	2.46	36.5	.28
20	.036	.0010	20.00	440.0	1.018	3.18	3 9	2.036	12.72	.97	3.05	28.62	.43	4.07	50.9	.24
19	.040	.0012	18 52	377.0	1.26	3.56	3.6	2.52	14.24	.92	3.78	32.04	.41	5.04	57.0	.23
18	.048	.0018	16.13	286.0	1.81	4.64	3.3	3.62	18.56	.83	5.43	41.76	.37	7.24	74.2	.21
17	.056	.0024	14.28	224.0	2.4	5.47	3.2	4.8	21.9	.79	7 2	49.2	.35	9.6	87.5	19
16	.064	.0032	12.83	181.0	3.2	6.57	3.0	6.4	26.3	.74	9.6	59.1	.33	12.8	105.1	.18
15	.072	.0040	11.63	149 0	4.0	7.40	2.9	8.0	29.6	.72	12.0	66.6	.32	16.0	118.4	.17
14	.080	.0050	10 64	124.0	5.0	8.46	2.8	10.0	33.8	.70	15.0	76.3	.31	20.0	135.4	.17
13	.092	.0060	9.44	98.2	6.6	9.97	2.7	13.2	39.9	.67	19.8	89.7	.30	26.4	159.5	.16
12	.104	.0085	8.48	79.1	8.5	11.53	2.6	17.0	46.1	.65	25.5	103.8	.29	34.0	184.4	.16
11	.116	.0105	7.69	65.0	10.5	12.8	2.5	21.0	51 2	.63	31.5	115.2	.28	42.0	204.8	.16
10	.128	.0128	7.04	54.5	12.8	14.3	2.4	25.6	57.2	.61	38.4	128.7	.27	51.2	228.8	.15
9	.144	.0163	6.33	44.1	16.3	16.4	2.4	32.6	65.6	.60	48.9	147.6	.27	65.2	262.4	.15
8	.160	.0201	5.74	36.3	20.1	18.4	2.3	40.2	73 6	.59	60.3	165.6	.26	80 4	294 4	.15
7	.176	.0243	5.26	30.4	24.3	20.4	2.3	48.6	81.6	.58	72.9	183.6	.26	97.2	326 4	.15
Stranded.																
7-22	0.84	.0043	9.62	101.8	4.3	6.73	4.0	8.6	26.9	.99	12.9	24 6	.44	17.2	107 7	.25
7-20	.108	.0072	7.81	67.1	7.13	8.94	3.7	14.3	35.7	.92	21.4	80.5	.48	28.5	143.0	.23
7-18	144	.0128	6.09	40.8	12.7	12.4	3.4	25.4	49.6	.83	38 1	111.6	.39	50.8	198.4	.21
7-16	.192	.0229	5.10	28.6	22.9	17.2	3.2	45.8	68 7	.79	68.7	154.5	.35	91.6	274.7	.20
7-15	216	.0289	4 27	20.1	28.9	19.5	3 1	57.8	78.0	.78	86.7	175.4	34	115 6	311.8	.20
7-14	.240	.0356	3 87	16.5	35.6	21.8	3.1	71.2	87 1	.76	106.8	195.9	.34	142.4	348.3	.19
7-13	.276	.0462	3.38	12.6	46.2	24.7	3.0	92.4	98.8	.74	138 6	222.3	.33	184.8	395 2	.19
7-12	.312	.0595	3.01	9.97	59.5	28 5	2.9	179.0	114.0	.72	178.5	256.5	32	238.0	456.	.18

Figures in columns marked A signify number of ampères that the wire carries.

Figures in columns marked F signify number of degrees (Fahrenheit, that the coil will warm up if there is only one layer of wire, and on the assumption that the heat is radiated only from the outer surface of the coil; they are calculated by the following modification of Forbes' rule:

Rise in temperature (Fahrenheit deg.) = 225 × No. of watts lost per sq. inch. ÷ 159 × sectional area × number of turns to 1 inch (at 1,000 amps. per sq. inch).

Figures in columns marked D are the depth in inches to which wire may be wound if 1 watt be lost by each square inch of radiating surface, the outside radiating surface of the bobbin being only considered.

Rule for calculating a 7-strand cable: Diam. of cable = 1.134 × diam. of equivalent round wire

Figures under heading "Turns to 1 linear inch" are calculated for cotton-covered wires of average thicknesses of coverings used for the different gauges, viz., 14 mils additional diameter on round wires (from No. 22), and 20 mils on stranded or square wire.

Figures under heading "Turns per square inch" are calculated from preceding, allowing 10 per cent. for bedding of layers.

Resistance (ohms) of coil of copper wire, occupying v cubic inches of coil space, and of which the gauge is d mils uncovered, and D mils covered, may be approximately calculated by the rule:

$$\text{ohms} = 960700 \frac{v}{D^2\ d^2}$$

The data respecting sizes of wires of various gauges are kindly furnished by the London Electric Wire Company.

For many purposes, such as for use in telegraphs and electric bells, smaller wires than any of those mentioned in the table are required. The table is, in fact, intended for use in calculating magnets in larger engineering work.

A rough-and-ready rule sometimes given for the size of wire is to allow $\frac{1}{1000}$ square inch per ampère. This is an absurd rule, however, as the figures in the table show. Under the heading 1,000 ampères to square inch, it appears that if a No. 18 S. W. G. wire is used, it will at that rate carry 1.81 ampères; that if there is only one layer of wire, it will only warm up 4.64 degrees Fahr., consequently one might wind layer after layer to a depth of 3.3 inches, without getting up to the limit of allowing one square inch per watt for the emission of heat. In very few cases does one want to wind a coil so thick as 3.3 inches. For very few electromagnets need the layer of coil exceed half an inch in thickness; and if the layer is going to be only half an inch thick, or about one-seventh of the 3.3, one may use a current density $\sqrt{7}$ times as great as 1,000 ampères per square inch, without exceeding the limit. Indeed, with coils only half an inch thick, one may safely employ a current density of 3,000 ampères per square inch, owing to the assistance which the core gives for the dissipation and emission of heat.

Suppose, then, we have designed a horseshoe magnet, with a core one inch in diameter, and that, after considering the work it has to do, it is found that a magnetizing power of 2,400 turns is required; suppose, also, that it is laid down as a condition that the coil must not warm up more than 50 degrees Fahr. above the surrounding air—what volume of coil will be required? Assume, first, that the current will be one ampère; then there will have to be 2,400 turns of a wire which will carry one ampère. If we took a No. 20 S. W. G. wire and wound it to the depth of half an inch, that would give 220 turns per inch length of coil; so that a coil 11 inches long and a little over half an inch deep (or ten layers deep) would give 2,400 turns. Now Table X. shows that if this wire were to carry 1.018 ampères it would heat up 225 degrees Fahr. if wound to a depth of 3.9 inches. If wound to half an inch, it would therefore heat up about 30 degrees Fahr.; and with only one ampère would, of course, heat less. This is too good; try the next thinner wire. No. 22 S. W. G. wire at 2,000 ampères to the square inch will carry 1.23 ampères, and heats 225 degrees if wound up 1.13 inches. If it is only to heat 50 degrees, it must not be wound more than one-quarter inch deep; but if it only carries current of one ampère it

* Cantor Lectures, No. 3, continued from THE ELECTRICAL WORLD, Nov. 1, 1890.

* The *watt* is the unit of rate of expenditure of energy, and is equal to ten million ergs per second, or to 1-746th of a horse power. A current of one ampère, flowing through a resistance of one ohm, spends energy in heating at the rate of one watt. One watt is equivalent to 0.24 calories, per second, of heat. That is to say, the heat developed in one second, by expenditure of energy at the rate of one watt, would suffice to warm one gramme of water through 0.24 (Centigrade) degrees. As 252 calories are equal to one British (pound Fahr.) unit of heat, it follows that heat emitted at the rate of one watt would suffice to warm 3.4 pounds of water one degree Fahr. in one hour; or one British unit of heat equals 1,058 watt seconds.

may be wound a little deeper—say to 14 layers. There will then be wanted a coil about seven inches long to hold the 2,400 turns. The wire will occupy about 3.85 square inches of total cross section, and the volume of the space occupied by the winding will be 26.95 cubic inches. Two bobbins, each 3½ inches long and .65 deep, to allow for 14 layers, will be suitable to receive the coils.

By the light of the knowledge one possesses as to the relation between emissivity of surface, rate of heating by current, and limiting temperatures, it is seen how little justification there is for such empirical rules as that which is often given, namely, to make the depth of coil equal to the diameter of the iron core. Consider this in relation to the following fact; that in all those cases where leakage is negligible the number of ampère-turns that will magnetize up a thin core to any prescribed degree of magnetization will magnetize up a core of any section whatever, and of the same length, to the same degree of magnetization. A rule that would increase the depth of copper proportionately to the diameter of the iron core is absurd.

Where less accurate approximations are all that is needed, more simple rules can be given. Here are two cases:

Case 1. *Leakage Assumed To Be Negligible.*—Assume $\mathbf{B} = 16{,}000$, then $\mathbf{H} = 50$ (see Table III.). Hence the ampère-turns per centimetre of iron will have to be 40, or per inch of iron 102; for $\mathbf{H}$ is equal to 1.2566 times the ampère-turns per centimetre. Now, if the winding is not going to exceed one-half inch in depth, we may allow 4,000 ampères per square inch without serious overheating. And the 4,000 ampère-turns will require 2-inch length of coil, or each inch of coil carries 2,000 ampère-turns without overheating. Hence each inch of coil one-half inch deep will suffice to magnetize up 20 inches length of iron to the prescribed degree.

Case 2. *Leakage Assumed To Be 50 Per Cent.*—Assume $\mathbf{B}$ in air gap $= \mathbf{H} = 8{,}000$, then to force this across requires ampère-turns 6,400 per centimetre of air, or 16,250 per inch of air. Now, if winding is not going to exceed one-half inch depth, each inch length of coil will carry 2,000 ampère-turns. Hence, 8 inches length of coil one-quarter inch deep will be required for 1 inch length of air, magnetized up to the prescribed degree.

WINDINGS FOR CONSTANT PRESSURE AND FOR CONSTANT CURRENT.

In winding coils for magnets that are to be used on any electric light system, it should be carefully borne in mind that there are separate rules to be considered according to the nature of the supply. If the electric supply is at *constant pressure*, as usual for glow lamps, the winding of coils of electromagnets follows the same rule as the coils of voltmeters. If the supply is with *constant current*, as usual for arc lighting in series, then the coils must be wound with due regard to the current which the wire will carry, when lying in layers of suitable thickness, the number of turns being in this case the same whether thin or thick wire is used.

If we assume that a safe limit of temperature is 90 degrees Fahr. higher than the surrounding air, then the largest current which may be used with a given electromagnet is expressed by the formula:

$$\text{Highest permissible ampères} = 0.63\sqrt{\frac{s}{r}}$$

where s is the number of square inches of surface of the coils and r their resistance in ohms.

Similarly for coils to be used as shunts we have:

$$\text{Highest permissible volts} = 0.63\sqrt{sr}$$

The magnetizing power of a coil, supplied at a given number of volts of pressure, is independent of its length, and depends only on its gauge, but the longer the wire the *less* will be the heat waste. On the contrary, when the condition of supply is with a constant number of ampères of current, the magnetizing power of a coil is independent of the gauge of the wire, and depends only on its length; but the larger the gauge the less will be the heat waste.

MISCELLANEOUS RULES ABOUT WINDING.

To reach the same limiting temperature with bobbins of equal size, wound with wires of different gauge, the cross-section of the wire must vary with the current it is to carry; or, in other words, the current density (ampères per square inch) must be the same in each. Table X. shows the ampèreages of the various sizes of wires at four different values of current density.

To raise to the same temperature two similarly shaped coils, differing in size only, and having the gauges of the wires in the same ratio (so that there are the same number of turns on the large coil as on the small one), the currents must be proportional to the square roots of the cubes of the linear dimensions.

Sir William Thomson has given a useful rule for calculating windings of electromagnets of the same type but of different sizes. Similar iron cores, similarly wound with lengths of wire proportional to the squares of their linear dimensions, will, when excited with equal currents, produce equal intensities of magnetic field at points similarly situated with respect to them.

Similar electromagnets of different sizes must have ampère-turns proportional to their linear dimensions if they are to be magnetized up to an equal degree of saturation.

It is curious what erroneous notions crop up from time to time about winding electromagnets. In 1869 a certain Mr. Lyttle took out a patent for winding the coils in the following way: Wind the first layer as usual, then bring the wire back to the end where the winding began and wind a second layer, and so on. In this way all the windings will be right-handed, or else all left-handed, not alternately right and left as in the ordinary winding. Lyttle declared that this method of winding a coil gave more powerful effects; so did M. Brisson, who reinvented the same mode of winding in 1873, and solemnly described it. Its alleged superiority was at once disproved by Mr. W. H. Preece, who found the only difference to be that there was more difficulty in carrying out this mode of winding.

Another popular error is that electromagnets in which the wires are badly insulated are more powerful than those in which they are well insulated. This arises from the ignorant use of electromagnets having long, thin coils (of high resistance) with batteries consisting of a few cells (of low electromotive force). In such cases, if some of the coils are short circuited, more current flows, and the magnetizing power may be greater. But the scientific cure is either to rewind the magnet with an appropriate coil of thick wire, or else to apply another battery having an electromotive force that is greater.

SPECIFICATIONS OF ELECTROMAGNETS.

One frequently comes across specifications for construction which prescribe that an electromagnet shall be wound so that its coil shall have a certain resistance. This is an absurdity. Resistance does not help to magnetize the core. A better way of prescribing the winding is to name the ampère-turns and the temperature limit of heating. Another way is to prescribe the number of watts of energy which the magnet is to take. Indeed, it would be well if electricians could agree upon some sort of figure of merit by which to compare electromagnets, which should take into account the magnetic output—*i. e.*, the product of magnetic flux into magnetomotive force—the consumption of energy in watts, the temperature rise, and the like.

AMATEUR RULE ABOUT RESISTANCE OF ELECTROMAGNET AND BATTERY.

In dealing with this question of winding copper on a magnet core, I cannot desist from referring to that rule which is so often given, which I often wish might disappear from our text-books—the rule which tells you in effect that you are to waste 50 per cent. of the energy you employ. I refer to the rule which states that you will get

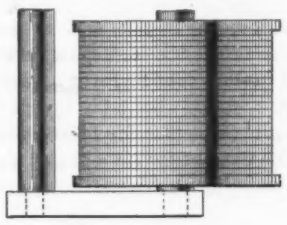


FIG. 50.

the maximum effect out of an electromagnet if you so wind it that the resistance is equal to the resistance of the battery you employ; or that if you have a magnet of a given resistance you ought to employ a battery of the same resistance. What is the meaning of this rule? It is a rule which is absolutely meaningless, unless in the first case the volume of the coil is prescribed once for all, and you cannot alter it; or unless once for all the number of battery elements that you can have is prescribed. If you have to deal with a fixed number of battery elements, and you have to get out of them the biggest effect in your external circuit, and cannot beg, buy, or borrow any more cells, it is perfectly true that, for steady currents, you ought to group them so that their internal resistance is equal to the external resistance that they have to work through; and then, as a matter of fact, half the energy of the battery will be wasted, but the output will be a maximum. Now that is a very nice rule indeed for amateurs, because an amateur generally starts with the notion that he does not want to economize in his rate of working; it does not matter whether the battery is working away furiously, heating itself, and wasting a lot of power; all he wants is to have the biggest possible effect for a little time out of the fewest cells. It is purely an amateur's rule, therefore, about equating the resistance inside to the resistance outside. But it is absolutely fallacious to set up any such rule for serious working; and not only fallacious, but absolutely untrue if you are going to deal with currents that are going to be turned off and on quickly. For any apparatus like an electric bell, or rapid telegraph, or induction coil, or any of those things where the current is going to vary up and down rapidly, it is a false rule, as we shall see presently. What is the real point of view from which one ought to start? I am often asked questions by, shall I say, amateurs, as well as by those who are not amateurs, about prescribing the battery for a given electromagnet, or prescribing an electromagnet for a given battery. Again, I am often told of cases of failure, in which a very little common sense rightly directed might have made a success. What one ought to think about in every case is not the battery, not the electromagnet, but *the line*. If you have a line, then you must have a battery and electromagnet to correspond. If the line is short and thick, a few feet of good copper wire, you should have a short, thick battery, a few big cells or one big cell, and a short, thick coil on your electromagnet. If you have a long, thin line, miles of it, say, you want a long, thin battery (small cells, and a long row of them) and a long, thin coil. That is then our rule: for a short, thick line, a short, thick battery and a short, thick coil; for a long, thin line, a long, thin battery and electromagnet coils to match. You smile; but it is a really good rule that I am giving you; vastly better than the worn-out amateur rule.

But, after all, my rule does not settle the whole question, because there is something more than the whole resistance of the circuit to be taken into account. Whenever you come to rapidly-acting apparatus, you have to think of the fact that the current, while varying, is governed not so much by the resistance as by the inertia of the circuit—its electromagnetic inertia. As this is a matter which will claim our especial attention hereafter, I will leave battery rules for the present and proceed with the question of design.

FORMS OF ELECTROMAGNETS.

This at once leads us to consider the classification of forms of magnets. I do not pretend to have found a complete classification. There is a very singular book written by M. Nicklès, in which he classifies under 37 different heads all conceivable kinds of magnets, bidromic, tridromic, monocnemic, multidromic, and I do not know how many more; but the classification is both unmeaning and unmanageable. For my present purpose I will simply pick out those which come under three or four heads, and deal separately with others that do not quite fit under any of the four categories.

Bar Electromagnets.—In the first place there are those which have a straight core, of which there are several specimens on the table here.

Horseshoe Electromagnets.—Then there are the horseshoes, of which some are of one piece, bent, and others here of the more frequent shape, made of three pieces.

Ironclad Electromagnets.—Then from the horseshoes I go to those magnets in which the return circuit of the iron comes back outside the coil from one end or the other, or from both ends, sometimes in the form of an external tube or jacket, sometimes merely with a parallel return yoke, or two parallel return yokes. All such magnets I propose to call—following the fashion that has been adopted for dynamos—ironclad electromagnets. One of them, the jacketed electromagnet, is shown in Fig. 12, page 222, and there are others not so well known. There is one used by Mr. Cromwell Varley, in which a straight magnet is placed between a couple of iron caps, which fit over the ends, and virtually bring the poles down close together, the circular rim of one cap being the north pole and that of the other cap being the south pole, the two rims being close together. That plan, of course, produces a great tendency to leak across from one rim to the other all round. The advantages, as well as the disadvantages, of the jacketed magnet I alluded to in my last lecture, when I pointed out to you that for all action at a distance it is far better not to have an iron-clad return path, whereas for action in contact the iron-clad magnet was distinctly a very good form. In one form of iron-clad magnet the end of the straight central core is fixed to the middle of a bar of iron, the ends of which are bent up and brought flush with the top of the bobbin, making thus a tripolar magnet, with one pole between the other two. The armature in this form is a bar which lies right across the three poles. There is an example of this excellent kind of electromagnet applied in one of the forms of electric bell indicator made by Messrs. Gent, of Leicester.

Then besides these three main classes—the straight bar, the horseshoe, and the ironclad—there is another form which is so useful and so commonly employed in certain work that it deserves to have a name of its own. It is that called by Count Du Moncel the *aimant boiteux*, or club-footed magnet (Fig. 50). It is a horseshoe, in fact, with a coil upon one pole and no coil upon the other. The advantage of that construction is simply, I suppose, that you will save labor—you will only have to wind the wire on one pole instead of two. Whether this is an improvement in any other sense is a question for experiment to determine, but on which theory perhaps might now be able to say something. Count Du Moncel, who made many experiments on this form of magnet, ascertained that there was for an equal weight of copper a slight falling off in power with the club-footed magnet. Indeed, one might almost predict, for a given weight of copper, if you wound all in one coil only, you will not make as many turns as if you wound it in two, the outer turns on the coil being so much larger than the average turn when wound in two coils. Consequently the number of ampère-turns with a given weight of copper would be rather smaller, and you would require more current to bring the magnetizing power up to the same value as with the two coils. At the same time the one coil may be produced a little more cheaply than the two; and indeed such electromagnets are really quite common, being largely used for the sake of cheapness and compactness in indicators or electric bells.

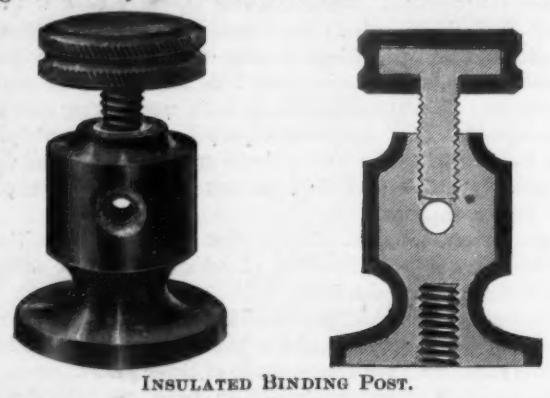
Du Moncel tried various experiments about this form to find whether it acted better when the armature was pivoted over one pole or over the other, and found it worked best when the armature was actually hinged on to that pole which comes up through the coil. He made two experiments, trying coils on one or the other limb, the armature being in each case set at an equal distance. In one experiment he found the pull was 35 grammes, with an armature hinged on to the idle pole, and 40 grammes when it was hinged on to the pole which carried the coil.

Another form of electromagnet, having but one coil, is used in the electric bells of church-bell pattern, of which Mr. H. Jensen is the designer. In Jensen's electromagnet a straight cylindrical core receives the bobbin for the coil, and, after this has been pushed into its place, two ovate pole-pieces are screwed upon its ends, serving thus to bring the magnetic circuit across the ends of the bobbin, and forming a magnetic gap along the side of the bobbin. The armature is a rectangular strip of soft iron, about the same length as the core, and is attracted at one end by one pole-piece and at the other end by the other.

(To be continued.)

An Insulated Binding Post.

It is sometimes a great convenience to have a binding post so thoroughly insulated that when it is placed on a high tension dynamo or motor it can be handled without

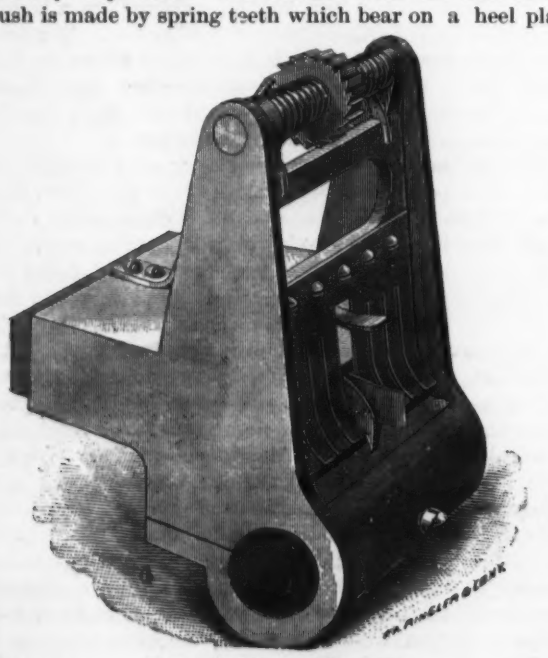


INSULATED BINDING POST.

fear of receiving an unpleasant shock. This is not always easy to accomplish unless the post is pretty thoroughly coated with some insulating compound. One of the neatest specimens of a special binding post for this class of work is the one illustrated herewith, which was designed by Mr. J. D. Claghorn for M. C. Chase, a well-known manufacturer of hard rubber in Chicago. The cut shows a sample of one of the styles now on the market. The outer casing of rubber is quite complete, and it is vulcanized on to the metal and finished afterward so as to form a smooth-polished and coherent coating throughout. Various sizes and forms are made and carried in stock, so that almost any requirement in insulated binding posts can be met at once. The insulation resulting from this process is certainly most thorough, and the new binding post should prove convenient in very many situations.

New Carbon Brush-Holder for Dynamos.

The brush-holder which is shown in the accompanying illustration is designed for use on existing dynamos fitted for copper brushes having a stud parallel to the commutator. The pressure of the brush on the commutator is carefully adjustable. The contact with the heel of the brush is made by spring teeth which bear on a heel plate



EMMET'S BRUSH HOLDER.

and make perfect contact. There is a spring pawl by which the brush and contact lever are held back when withdrawn, the heel plate of the brush being hooked to the lever. This admits of the brush being withdrawn from the commutator without removing it from the holder or changing its tension or setting. The holders are so shaped that they take up the least possible amount of room on the commutator, and the brushes are thus as large as could in any case be used. These brush-holders are manufactured by Emmet Bros., 150 Broadway, this city. Nine 500-volt dynamos, belonging to the Pleasant Valley Railroad, of Pittsburgh, Pa., have run for a year with these brush-holders, often with overloads, and the commutators show no perceptible wear, and the service of the brushes is in every respect all that could be desired. The East Cleveland Railway Company has had the same experience with six No. 32 Edison generators fitted with these holders six months ago. The holders are suitable for all dynamos of 300 volts potential or over.

An Important Decision in Pennsylvania.

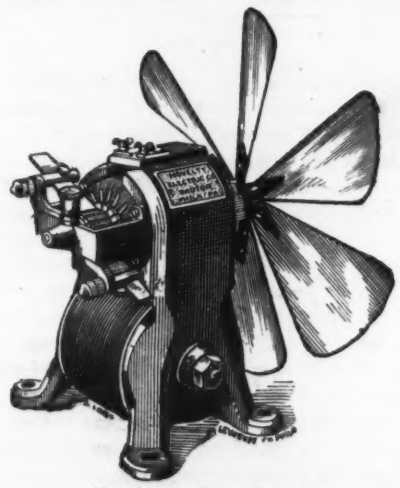
A decision and opinion just handed down by Judge Archibald, of Lackawanna County, Pa., is of considerable interest and importance. In this opinion, rendered in the case of the city of Scranton vs. the Scranton Electric Light and Power Company, the court, in brief, holds that the property necessary to carry out the corporate purposes of a corporation engaged in business of a public interest is not liable to local taxation, where such property is included in the capital stock which pays a state tax. That only those corporations which owe a well recognized duty to the public and which hold their property and exercise their franchises in subjection to that duty, fall within this class. That an electric light company, incorporated under the acts of April 29, 1874, and June 2, 1887, to supply light, heat and power to the public, belong to this class; and its lands, buildings and appurtenances, necessary to carry out its corporate porposes, are exempt from local taxation, where such property is included in the capital stock, which pays a State tax.

A New-comer Among Motors.

We show herewith a neat little motor now being manufactured by the Novelty Electric Company, of Philadelphia. It will be seen that it is a very simple, strongly made little

THE NOVELTY ELECTRIC MOTOR.

machine, compact in design, and magnetized by a single coil of wire in much the same way as the new United States type of motor. The styles at present made comprise a small fan motor, one of about ⅛ h. p. and one of ¼ h. p. They are, so far, all built for the 110-volt circuit of constant potential. The two larger sizes are of the styles just mentioned. The small fan motor is wound on a little different



NOVELTY FAN OUTFIT.

pattern. Graphite bearings are used to reduce friction and obviate the inconvenience of frequent oiling; and the fan motors, if desirable, can be arranged to connect on an ordinary incandescent lamp socket. The cost of running the three sizes is said to be 3, 4 and 5 cents a day respectively in ordinary service. The new motor seems to be one of the convenient and simple little machines now coming into such extensive use for driving fans and light machinery. There is a constantly increasing demand for such machines, and the new-comer ought to take its share in the wide field which exsts throughout the country for this kind of electrical apparatus.

A Medical Examination by Telephone.

According to an English journal, Tickleribs is a practical joker, but he is very much afraid of consumption. The other evening he began coughing, and went to the telephone and called up Dr. Whiteye, and told him he was pretty sure he was in the first stage of consumption.

Now it may be stated by way of parenthesis that Tickleribs had played a good many jokes on the girl at the central call-office, so as soon as she heard what he said she rang up a music shop where a young man is in the habit of practicing upon a bass horn about that time, and told him in her sweetest tone that she would like him to blow a short sharp blast right in front of the transmitter of his telephone as soon as he heard the bell tinkle. The young man got ready.

"Oh! I fancy you're mistaken," said the doctor.

"No, I ain't. Lose no time. Come over at once."

"Hold on! Cough in the telephone."

The girl, who had been listening, jerked out the plug connecting Tickleribs, put that connecting the bass horn in its place, and tinkled the bell according to previous arrangement.

The young man dropped the receiver from its hook and blew a terrible blast. The girl immediately restored the

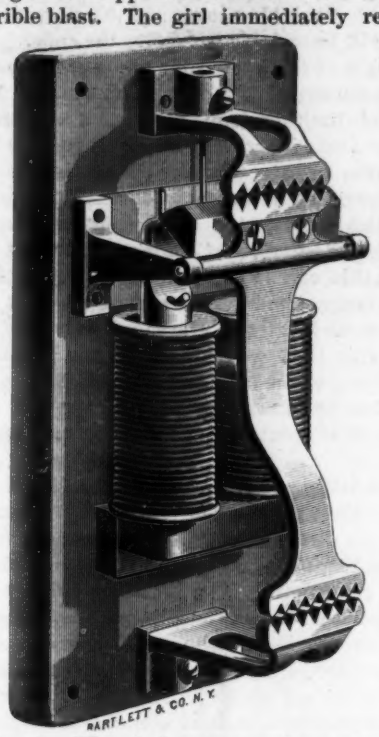


FIG. 1.—WOOD'S LIGHTNING ARRESTER.

connection, and the doctor, after recovering from his astonishment, asked:

"Did you cough?"

"Yes; ain't it pretty bad?"

"I should say so!" exclaimed the doctor.

"What shall I do?"

"Confine yourself to a diet of oats and baled hay."

"Oats and baled hay! What do you mean?"

"Why, you are turning to a jackass very rapidly, and you had better begin your new way of living at once. You have symptoms of the consumption of oats and baled hay."

While the doctor wondered and the patient raved the telephone lady split her sides with laughter, and the innocent young man tooted his horn in ignorance of what he had done.

New Lightning Arrester.

Mr. James J. Wood, electrician of the Fort Wayne Electric Company, is the inventor of a new lightning arrester shown in the accompanying cuts. Fig. 1 shows the arerster in position. Fig. 2 shows it with the arc breaker

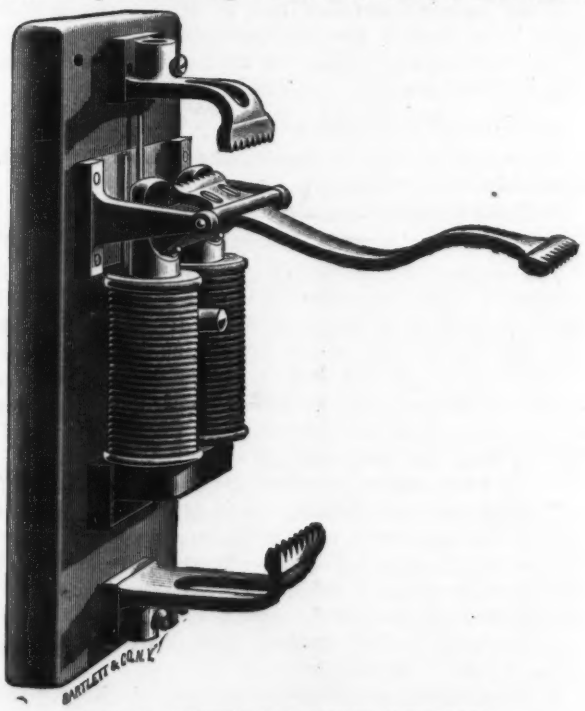


FIG. 2.—WOOD'S LIGHTNING ARRESTER.

thrown up. The line runs from the dynamo through the switchboard, out to the lightning arrester on the positive wire, thence through the lamps back to the arrester on the negative wire, to the switchboard and dynamo.

The chief claim of this lightning arrester is that the lightning has a free passage from the line to the ground, no magnets being in the ground circuit to offer resistance, and, if the current attempts to follow it, will form an arc across the lower set of pointers, but in attempting to cross the upper set a part of the current is shunted into the magnets and these attract the armature which is attached to the upper part of the arc breaker, thus throwing the lower end outward and breaking the arc as shown in Fig. 2, and this end will immediately fall back into position and be ready for another discharge.

Lightning arresters are now rightly regarded as a very important factor in the safety of electric plants, and managers will welcome any improvement in this line.

Investigation of the Stanley Alternate Current Arc Dynamo.*

BY W. B. TOBEY AND G. H. WALBRIDGE.

Before entering directly upon the subject to be presented this evening, *i. e.*, the investigation of the Stanley alternate current arc dynamo, it may be well to give a brief description of that new and extremely novel type of machine. Descriptions of it have been given in some of the electrical papers during the past spring, but some here may not recall its general mechanical construction. The dynamo is manufactured and sold by the Westinghouse Electric Company under patents granted to Mr. Wm. Stanley, Jr., the inventor. Mr. Albert Schmid, superintendent of the Westinghouse Electric Company's shops, deserves much credit for perfecting the machine in detail, and to him is largely due its success commercially. In general appearance it closely resembles the Westinghouse alternate current constant potential dynamo, which has become so familiar to all. In fact, the frame, pole pieces, field windings, etc., for any given size machine are identical, whether for constant current or constant potential. The distinguishing feature between them lies wholly in the form and winding of the armatures. Figs. 12 and 13, showing diagramatically half-sections of the machine, will aid us in a description of the armature, which is built up of thin iron plates stamped in the form shown. It will be observed that a number of cores corresponding to the number of poles on the dynamo project radially from the armature, and from the sides of each core project overlapping lugs. The armature coils are not of the original "pan-cake" or oblong flat coil type, placed on the periphery of the armature, but are quite thick, and placed around the core projections. The overlapping lugs serve the double purpose of preventing the coils from slipping off the cores, and also aid in the regulation of the machine. All the armature coils are connected in series and the terminals connected to the two collector rings, upon which bear the brushes furnishing current to the line. The field coils are also in series so connected that the poles presented to the armature are of alternate polarity. The terminals of the field go directly to a small shunt-wound exciter. Thus it is seen that the machine consists simply of an even number of field coils, corresponding to the number of poles on the machine, joined in series, and an equal number of armature coils also joined in series. That from such a simple combination of coils without any external regulating device an almost constant current is obtained for all loads, from short circuit to the maximum output of the machine, seems incredible, but such is the case.

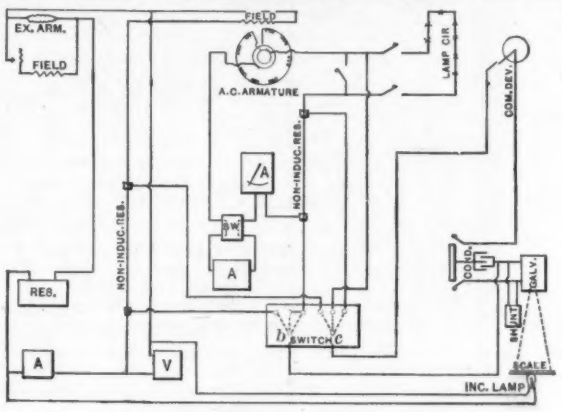


Fig. 1.—DIAGRAM OF CONNECTIONS.
A, A, A. Ammeters; V. Voltmeter.

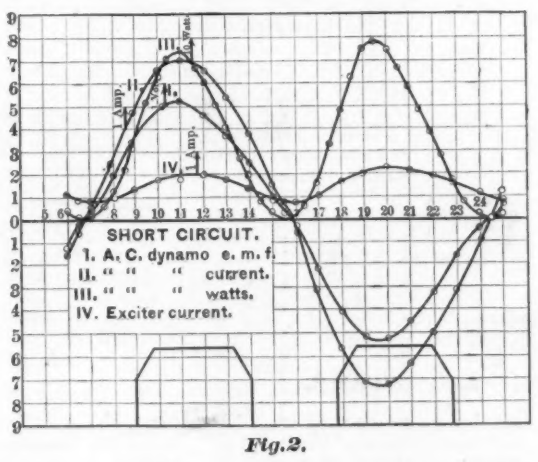


Fig. 2.

Through the kindness of Mr. Stanley, a complete 40-light plant was sent the writers at Cornell University, at which institution we were then students. Later, the Westinghouse Company made the University a gift of the entire plant. It has been our aim to show how the regulation takes place; also, to determine the actual electrical output of the machine, and from the latter and the corresponding dynamometer readings to calculate the efficiency of the dynamo.

The alternator was mounted on a Brackett cradle dynamometer calibrated to read in watts direct at 1,000 revolutions, the speed at which we were running.

The general method has been to obtain instantaneous values of E. M. F. arc and exciter currents at a sufficient number of points to indicate by curves the performance of the dynamo at every part of a revolution. For this purpose runs were taken with the dynamo at short circuit and with loads of 5, 10, etc., up to 40 lamps. The dynamo was run under normal conditions, viz., at a speed of 1,000 revolutions, and with such excitation as to cause an output of approximately 10 ampères. For obtaining values of E. M. F. at low loads pressure wires were run from the terminals of the dynamo, and for larger loads, were taken from around 10 lamps. At all points where instantaneous values of E. M. F. were taken corresponding values of arc and field or exciter currents were obtained by "fall of potential" method. Pressure wires were brought from the terminals of each of two non-inductive resistances of German silver wire placed in arc and field circuits. (See Fig. 1.) These resistances being constant, any pressure around the terminals corresponded to a certain current. The terminals of the three pairs of pressure wires were connected to the contacts of the triple-throw switch, so that by placing the switch on any pair of contacts desired those terminals could be put in circuit with a line in which was a condenser and the revolving contact or commutating device by means of which the condenser was charged. The revolving contact used was similar to the one described in detail by Prof. Ryan in his article on "Transformers" read before the Institute last December. It consisted essentially of a knife edge of steel fastened by a wooden clamp to the collector end of the armature, and revolving with it through a circle of about eight inches diameter. The centre of the knife edge was in line with the centre of one of the armature coils. Upon a frame at the same end of the armature was held a wooden semicircle, upon the periphery of which was a paper scale, divided to millimetres. At the centre of the semicircle was pivoted an arm carrying a brush holder, in which was a steel spring. The brush holder was so adjusted that the revolving knife edge made contact with the spring several times per second. The arm carrying this spring could be clamped wherever desired, and its position designated by means of a pointer over the scale.† Thus the condenser, placed in series, could be brought to the same difference of potential that existed between the spring and the knife edge. The arc circuit was, as shown by the diagram of connections, Fig. 1, taken from one brush directly to a Westinghouse ammeter through a switch, by means of which a Thomson balance, or gravity ammeter, could be put in circuit when desired. From the Westinghouse ammeter the current was taken through the non-inductive resistance to the dynamo short-circuiting switch, where the other terminal of the machine was directly connected. The exciter current was measured by a Ryan gravity ammeter, and a Hartmann and Braun type voltmeter indicated the potential around the terminals of the field. The arm of the commutating device being clamped at some desired position, the spring was adjusted so that the revolving knife edge made contact; then the switch was thrown on any one of the three pairs of terminals for the circuits of which we wished to obtain instantaneous values. The half microfarad condenser was so connected that by closing a key it would be charged. Opening this key and closing one in circuit with the galvanometer sent the charge through the galvanometer and the throw was noted.

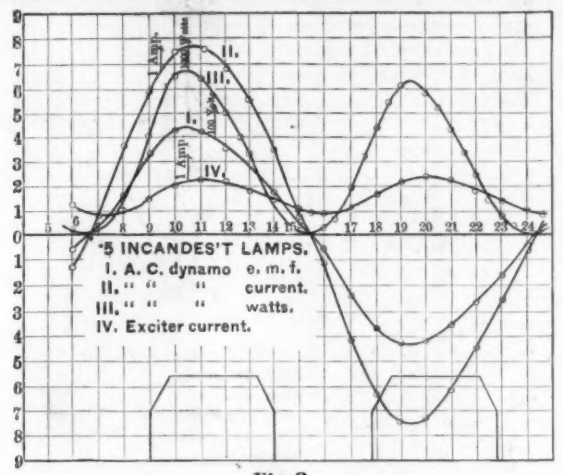


Fig. 3.

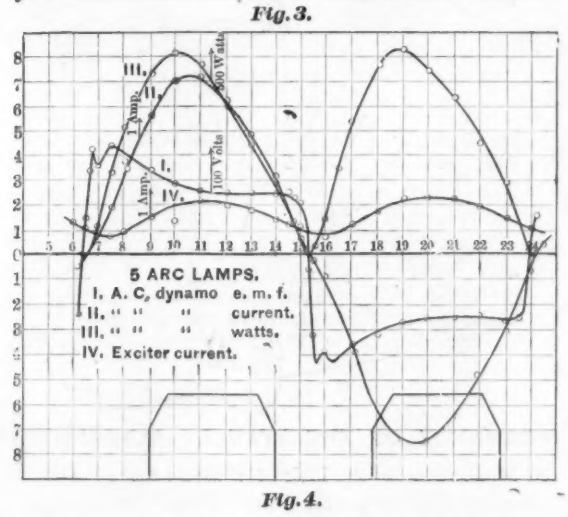


Fig. 4.

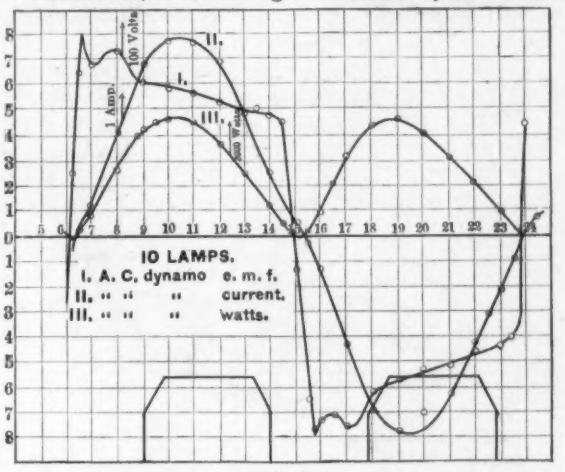


Fig. 5.

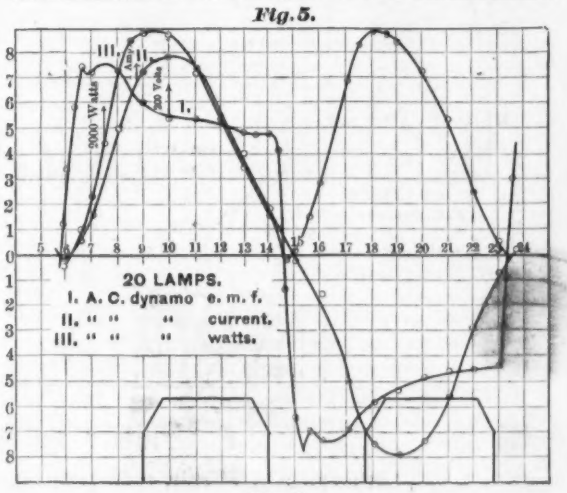


Fig. 6.

FIGS. 1 TO 6.—PERFORMANCE OF THE STANLEY ALTERNATE CURRENT ARC DYNAMO.

The galvanometer used was of 5,000 ohms resistance, and consisted of the coil of a Sir Wm. Thomson marine galvanometer, in which was suspended a small, concave mirror, having several very small magnets, constituting the needle fastened on the back. The controller was a large horseshoe magnet. A simple wooden frame supported the coil. A narrow slit in a screen, behind which stood an incandescent lamp, allowed an image of part of the filament to fall on the galvanometer mirror and be reflected back to the screen, on which was a graduated scale. By placing a resistance box in shunt around the galvanometer, the throw of the needle was reduced when it was desired to read the arc E. M. F. When current readings were taken the whole charge of the condenser was passed through the galvanometer. The galvanometer was calibrated for E. M. F. by putting the condenser and a standard potential instrument in multiple around the terminals of a storage battery giving about 120 volts. Readings were then taken of the voltage, and the corresponding throw of the needle was noted. The calibrations for currents were made by running the exciter alone, and passing the current through both of the non-inductive resistances, determining its amount by an ammeter, and observing the corresponding throw of the galvanometer needle for each non-inductive resistance.

So much for a description of the dynamo, the instruments and the methods used. We now come to that which is of the most interest, viz.: the results obtained. In order that the curves may be more easily followed, we will give a brief general explanation of them.

The figures of the zero line, always commencing with 5, correspond to the divisions on the scale of the wooden semi-circle, a part of the commutating device. Under each plate of curves will be seen two rectangular figures, representing pole-pieces, which show the relative position of the curves with respect to the poles. From each curve projects a vertical arrow, always equal to one or two divisions, and its value marked near it. In all curves the direction of motion of the armature relatively to the poles is from left to right.

Fig. 2 represents the performance of the machine at short circuit. The curves of E. M. F. and current both approach sine curves; the current rising almost in unison with the E. M. F., there being no perceptible lag. The curve of exciter current in this, as in all cases, exhibits a wavy form. Fig. 12 shows the position of the armature relatively to the poles when the E. M. F. is zero and the machine running on short circuit.

Fig. 4, representing the curves for a load of five arc lamps, shows a radical change in the E. M. F., which now approaches more nearly to the form of a rectangle than a sine curve, and immediately after passing the zeros exhibits very sharp peaks. In this case the current continues to rise after the E. M. F. has begun to fall, and also lags slightly with respect to it. A shifting of the zeros has also taken place. Comparing this E. M. F. curve with that for short circuit, it is seen that the first zero shown

* A paper read before the American Institute of Electrical Engineers, New York, Oct. 21, 1890.

* See *Transactions*, Vol. VII., p. 1.

† Much trouble experienced by other investigators in this line, due to breaking of the springs, was entirely obviated by us by putting a piece of thin rubber packing above the spring where it was clamped in the brush holder.

occurs at about 6.35 instead of 6.85. The curves for all loads of arc lamps are quite similar in form, as will be seen by referring to Figs. 5, 6, 7 and 8. As the load is increased, however, the zeros occur earlier with respect to the poles, and the current lag increases slightly. The efficiency curve, Fig. 9, tells the story of the dynamo from a commercial point of view, reaching as it does an efficiency of between 93 per cent. and 94 per cent. at full load, while at half load it is 92 per cent.

A most interesting set of curves is shown in Fig. 10, giving a comparison of the forms and values of E. M. F. for 40, 30, 20 and 10 lamps, their position with respect to the poles, and also the position of the zeros of E. M. F. at short circuit.

Figs. 13 and 12 show respectively the positions of the armature relatively to the poles for full load and short circuit.

An apparently remarkable feature of the machine is that it may be short circuited when running at full load, without the slightest injury, and it may be run at short circuit indefinitely. That the machine regulates with great rapidity is proven by the fact that upon short circuiting it the ammeter indicates but a slight increase of current. The peculiar form of the E. M. F. curve for arc lamps led us, so far as time would permit, to an investigation of the cause, to ascertain which the following runs were taken:

First, with a non-inductive resistance of five large incandescent lamps, but no arcs in circuit; each lamp consuming about the same amount of energy as an arc lamp. Second, with nothing but an inductive resistance, consisting of a solenoid having 440 turns of No. 10 wire. The curves in both cases were similar and approached sine curves, proving the rectangular form to be due entirely to the action of the arc. Fig. 3 shows the curves obtained from the load of incandescent lamps. To more fully determine this action with no other resistance in circuit, an arrangement was made whereby an arc could be regulated by hand with the aid of a hot wire voltmeter. We took no curve for a single lamp under normal conditions with which to compare the one taken in the above manner; but the latter (see Fig. 11) has very high and abrupt elevations of E. M. F. immediately before and after passing the zeros. The theory advanced to explain the high point of E. M. F. in all the arc curves is that, when the arc breaks, the rush of cold air adding resistance to the circuit prevents the arc forming again until the potential has risen to a point considerably higher than that required to maintain an arc once formed. To test this we attempted to heat an arc by means of an alcohol blast, and thus prevent, in a measure, the rush of cold air. This means of heating proved inadequate, so that the results were not all that could be desired. As before stated, we had no one-lamp curve with which to compare it, but as compared with the one lamp regulated by hand the sharp corners of E. M. F. were much modified. It is not certain, however, whether this was due to the action of the lamp regulating coils or to the action of the flame. The current curve in all cases approaches a sine curve in form, but is always slightly steeper on the left or front side; direction of rotation being from left to right. Although the current lag is practically nothing at short circuit, or for any load except arc lamps, it increases slowly as arc lamps are added. For 40 lamps it is about 4½ per cent. of the time of an alternation. The wavy form of the exciter current is probably caused by the variable resistance of the magnetic circuit due to the projecting cores and lugs of the armature as they approach and recede from the poles. The values of E. M. F. and current were found by taking the square root of the mean square of 36 ordinates of a curve, representing a complete cycle. Although the current lag was very small, the product of the values of current and E. M. F. obtained as above did not give the watts. The watts were obtained by plotting a curve, the points of which were the products of the instantaneous values of E. M. F. and current; then integrating by a planimeter. Dividing the value of the watts thus obtained by the current, we obtained a value of the E. M. F which was usually about seven volts lower per lamp than the corresponding value obtained from the square root of the mean square. This difference was, no doubt, due to the extremely high values of the E. M. F. when the current was very low, as the negative work was negligible. To distinguish between the two values we have called the one obtained from the square root of the mean square the "actual" E. M. F., while the one obtained by the second method has been called the "effective" E. M. F. it alone being effective in doing work on the circuit.

It is very much of a question in our minds as to whether the square root of the mean square, obtained from the rectangular E. M. F. curves for arc lamps, gives the actual E. M. F.; but for the lack of a better term the values thus obtained have been called the "actual" E. M. Fs.

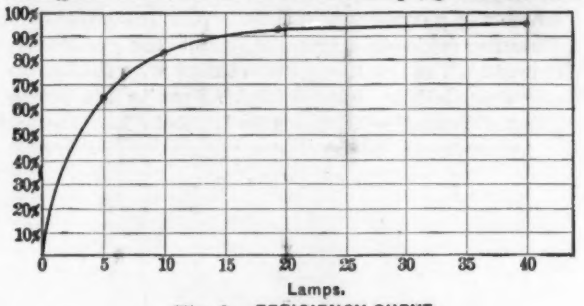


Fig. 9.—EFFICIENCY CURVE.

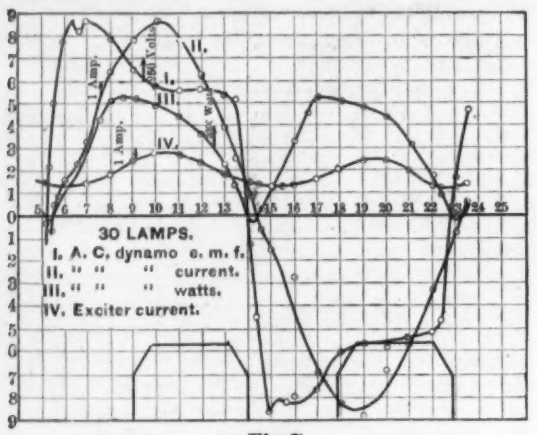


Fig. 7.

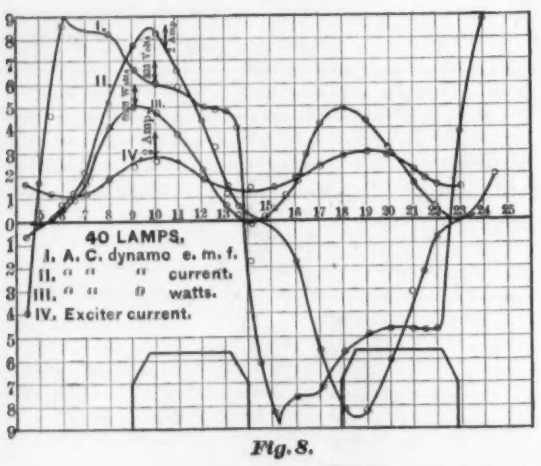


Fig. 8.

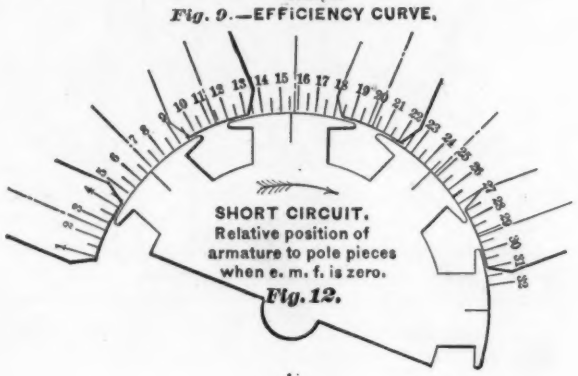


Fig. 12.

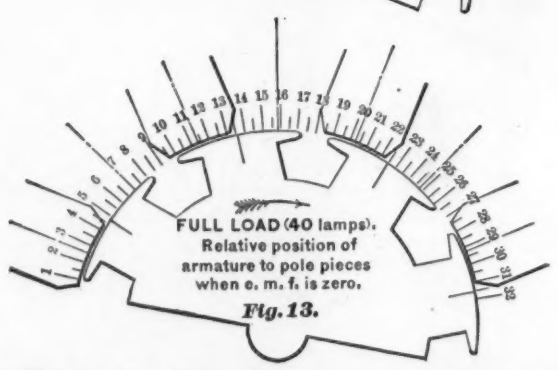


Fig. 13.

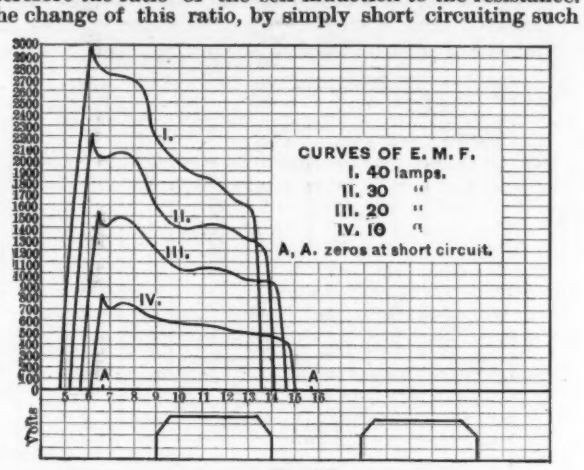


Fig. 10.

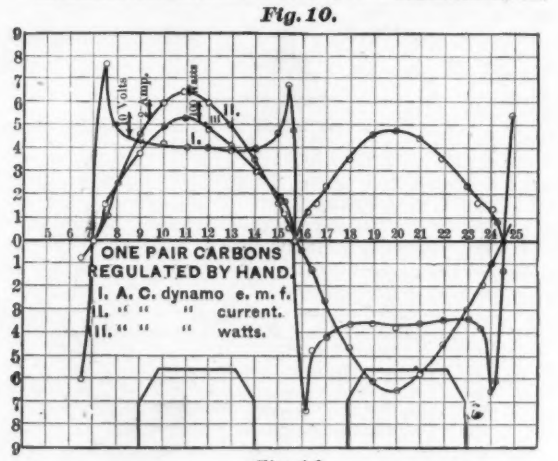


Fig. 11.

FIGS. 7 TO 13.—PERFORMANCE OF THE STANLEY ALTERNATE CURRENT ARC DYNAMO.

TABLE OF DATA.

	√Mean sq. of E.M.F.	Volts per l'mp "actual."	√Mean sq. of current	Volts per l'mp "effective."	Mean watts electrical.	Watts excitation.	Mean watts by dynameter.	Efficiency.
Short circuit	3.53	....	9.78	...	35	155	1,780	.....
5 incandescent	289	57.8	10.32	59.3	3,060	158	3,900	75.3%
5 arc	285	57	9.98	50	2,500	165	3,584	66.6%
10 arc	.....	....	10.7	53.3	5,700	190	6,630	83.5%
20 arc	1100	55	10.36	48.3	10,000	190	10,680	92.3%
30 arc	.....	....	.....	.....	.....	204	12,120	.....
40 arc	.....	....	9.82	41	16,000	240	16,950	93.2%
1 pair carbons	42	42	8.86	35.5	314	....	.....	.....

For arc current values we have assumed the square root of the mean square to be correct, and if not actually the case, they are certainly very close approximations, as the current curves are practically sine curves.

The exact values of E. M. F. or current are of little consequence, however, except as a matter of interest, since the electrical output in watts is known, this alone being required to determine the efficiency.

In conclusion, we can simply state, what our investigations have shown, that the dynamo, aside from being very efficient and of most excellent regulation, is as stated at the beginning, an extremely novel and interesting type of machine.

DISCUSSION.

After this interesting paper by Tobey & Walbridge, Mr. Thorburn Reid's paper on "A New Method of Analysing Armature Reactions, Applied to the Stanley Arc Light Alternating Current Machine," was read. It was intensely mathematical in its treatment of the subject and furnished some interesting approximations to the theory of the electrical phenomena on which the remarkable self-regulation of the Stanley machine depends. Then a discussion on the two papers was opened and the institute listened with the greatest attention to the too brief remarks of Mr. Stanley himself on this topic. He gave, in the following condensed form, a general explanation of the machine under discussion:

The papers that have been read this evening refer to the regulation of a dynamo with which there is no external appliance to control the current. In applying an alternating potential to a circuit, there are two kinds of opposition to current flow. One kind is offered by the resistance of the circuit, determinate in the dimensions of the circuit, and the specific material of which it is composed, while the other is the opposition due to the shape of the circuit, that which we ordinarily call the self-induction of the circuit. Now the relation of these two oppositions to the flow of current is not exactly the same. The resistance of the circuit opposes the flow of the circuit at the instant the potential is applied. The counter-electromotive force of self-induction first delays the flow of current and then eggs it on, and the time that elapses between the application of a given potential to a circuit and the flow of current corresponding to any particular value of the potential is determinable by the ratio of the value of the self-induction to that of the resistance. Now, in this machine that these gentlemen have spoken of, we may consider that all that part of the circuit which is inside of the machine, viz.: the armature coils, represents the self-induction part of the circuit. This portion, therefore, tends to delay the flow of the current for a while, and afterwards to push it on. All that part of the circuit external to the machine may be considered to represent the resistance portion of the circuit. Now, it is evident we cannot change the number of turns of wire, or very well the number of revolutions of the machine when running; consequently we cannot change the value of the self-induction in circuit and therefore the ratio of the self-induction to the resistance. The change of this ratio, by simply short circuiting such arc lamps as we may wish to turn out, changes the time of the appearance of the current. It lets the armature of the machine get a little further ahead when one lamp is burning, when the maximum value of the current in the armature occurs; that is, it allows the armature pole to come up in front of the field pole as shown in Fig. 10 and to oppose the field pole (the magnetization in the armature being directly opposite to that in the field), it keeps the lines of the field magnetism from passing through the armature. This effect is very beautifully shown by winding on the armature two circuits, one an arc circuit and another a few turns of wire connected with the volt metre, both wound upon the same tooth. If the machine be short circuited, the magnetism is, as it were, blown out, and no potential is found upon the supplemental circuit. The whole regulation of the machine is due, then, to the fact that, as shown in Fig. 10 of Tobey & Walbridge's paper, the time of the current flow has advanced, as we see it, from the point AA of the horizontal line to the point near the numeral 5—13½. If we could put upon the field of the machine a separate circuit, and as fast as we turned out the arc lamps that we wished to compensate for, put a current through that circuit, decreasing the field strength, we would obtain exactly the same results the machine attains by its own armature action.

Mr. A. E. Kennelly then spoke of the great commercial importance of fully developing the theory of armature reactions, especially in the case of alternating currents. In continuous current machines the conditions are somewhat simpler, but in alternating current theory the most careful investigation is absolutely necessary, and even now our best work is only approximate. Mr. T. D. Lockwood then added some interesting facts to the discussion by speaking of the early use of the alternator, especially for arc lighting. He called attention to the fact, not generally known, that the first machine ever used for this purpose was an alternating machine—the Von Malderan—which has achieved better success in arc lighting than the earlier forms of direct current machines. Of course, it was but a crude attempt, for they were simply the most rudimentary efforts of the engineer in a slightly improved form, and were not at all worked out theoretically in the way that has now done so much to secure the success of the alternating system. After some brief further remarks Mr. Charles Steinmetz gave a most interesting critique on Mr. Reid's paper, and called attention to the fact that certain quantities had been assumed

constant which were evidently distinctly variable. His remarks were so thoroughly pertinent to the question that they possess unusual interest of their own quite aside from the paper on which they were passed. Mr. Steinmetz said :

In looking through the equations given here by Mr. Reid I see the magnetism of the field, called N, is supposed to be constant. Therefore, the magneto-motive force of the field magnetism, that is the exciting current, is supposed to be constant, too. But that will hardly ever be so, because of the induction, which the varying magnetism produces in the field circuit.

Now, here in the diagrams given by Mr. Tobey and Mr. Walbridge, I see the instantaneous values of the exciting current varying by more than 50 per cent. Therefore, it would follow that the field magnetism is varying in the same manner in that kind of alternating generator, and I could not think the equations to be complete, if the field magnetism is supposed to be constant. To complete the equations, there ought to be added to the term N, another factor, *f. i.* of the form: $1-\varepsilon \sin^2(\theta-\omega)$, where εN is the amplitude of the variations of exciting current ω, its angle of lag.

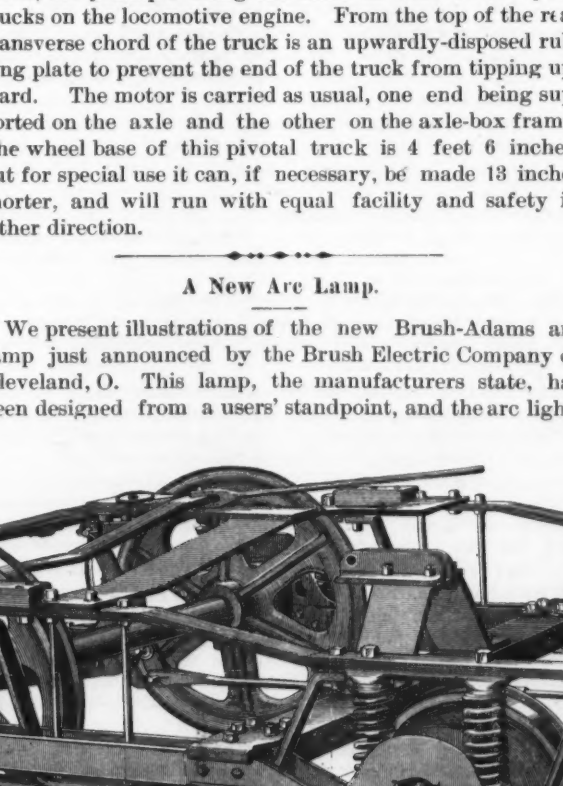
Furthermore here I see the magnetism A is supposed to be proportional to the magneto-motive force over the magnetic resistance. And this magnetic resistance is supposed to be constant. I think it would make a certain difference in these equations if also this assumption of the constancy of magnetic resistance should be abandoned as not being quite true. And then I think also here another term ought to be added ; but if this should be done those equations become so complicated indeed that I hardly think it possible to integrate them. (Laughter).

I saw the importance of this reasoning some time ago. I had to test a certain kind of alternator of about the same type as the new Thomson machine a short time before this was brought out. In this machine the induction was produced by changes of the magnetic resistance, and neither the armature coils nor the field coil were movable. By a calculation similar to the equations here given, where I supposed the exciting current to be constant, and therefore the magneto-motive force of the field constant, too, I found an electromotive force of I think 500 or 600 volts. But, after I experimented with the machine, I found the very high voltage of 22 volts! (Laughter.) In this set of tests I used as an exciter the current derived from a storage battery of about 30 volts. Now I tried to find out the reason of this very curious phenomenon, and, suspecting the reaction upon the field current, I used an exciting current which was more likely to be constant, the current of a constant current dynamo, connected in series with a large storage battery and two transformers with open secondaries, as choking coils, so that I was sure that very heavy self-induction and polarization straightened the wave of the exciting current. I got for exactly the same number of exciting turns and the same strength of current, and the same number of periods, the voltage of the dynamo up to 160 volts, still much lower, indeed, than calculated. So that this consideration seems to be rather important.

After further discussion by Mr. C. O. Mailloux, Dr. M. I. Pupin made some interesting comments on the paper of Messrs. Tobey and Walbridge, and called special attention to the singular form of curve of electromotive force given by the Stanley machine. He pointed out that the high initial values at the beginning of each period were probably due not to the cause supposed by the authors, but to the real varying resistance of the arc. As the current passed through, it varied, the maximum of current would correspond with the minimum of resistance and, conversely, the minimum current with the maximum of resistance; consequently, at the beginning of a period when the current is small, the resistance is high, and with a machine so responsive as the one under discussion, the electromotive force consequently rises sharply to fall again as the arc is established and the current becomes greater. Further discussion by Dr. Hutchinson, Mr. Reid and Mr. Steinmetz terminated the consideration of the remarkable dynamo which has attracted so great attention on the part of electrical engineers.

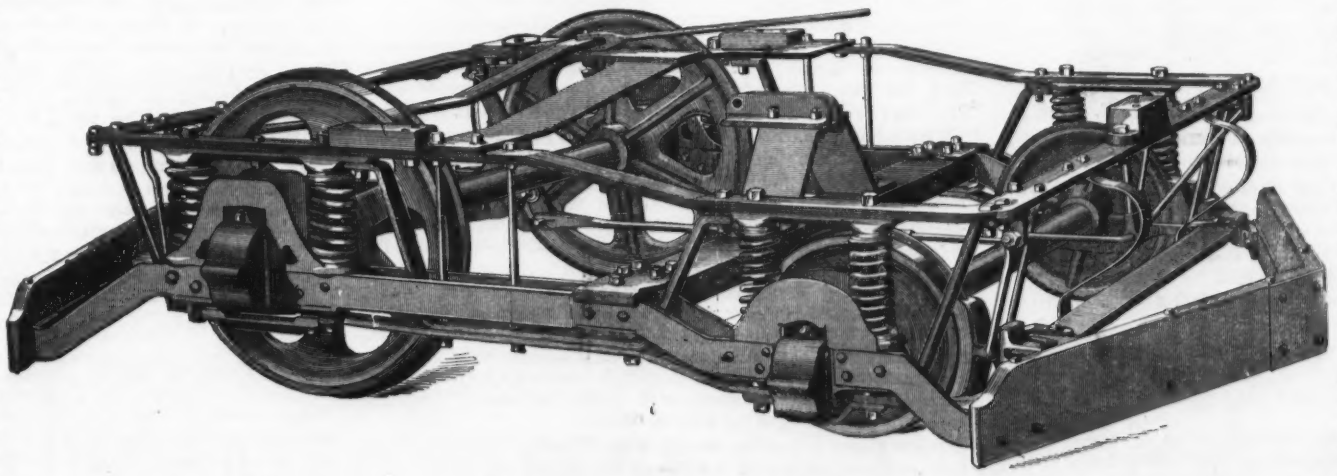
A New Brill Truck.

The requirements of electric traction have brought out a large number of new forms of car truck, and inasmuch as the most recent practice seems to tend to the use of double truck cars, various forms of special truck have been devised to meet the present requirements of the situation. One of the common disadvantages in such trucks is that the car body often has to be raised so far that where 30-inch car wheels are used, two steps are necessary. This, and similar disadvantages, have been in a great measure avoided in a recent form of truck devised by the J. G. Brill Company, of Philadelphia. In this case, as will be seen from the cut, the driving wheels operated by the motor are 30 inches in diameter while the rear, or trailing wheels are only 18 inches in diameter. The pivot in the centre may be within the periphery of the driving-wheels and anywhere between the centre of the truck and the centre of the driving axle; in other words, out of the central point where the pivot is usually placed so as to carry the weight of the car on the outside chord, the centre pivot plates being used merely to draw the car, and fastened to ½ inch iron plates arched up into the well of the car bottom. The driving wheels then set up under the car between the outside and inside sills, and as the pivotal centre is so close to them they will swing between two sills on curves as low as 30 feet radius. Between 75 and 80 per cent. of the weight on the trucks is then brought directly upon the driving axles, and in addition, the height of the car body from the rails is an inch lower than that of most cars mounted on the ordinary independent rigid truck. The rear wheels are made small for the double purpose of allowing that portion of the truck to swing clear of the car body and also to present more flange to the rail and prevent them running off the



THE BRUSH-ADAMS ARC LAMP.

track, the principle being the same as that of the pony trucks on the locomotive engine. From the top of the rear transverse chord of the truck is an upwardly-disposed rubbing plate to prevent the end of the truck from tipping upward. The motor is carried as usual, one end being supported on the axle and the other on the axle-box frame. The wheel base of this pivotal truck is 4 feet 6 inches, but for special use it can, if necessary, be made 13 inches shorter, and will run with equal facility and safety in either direction.



NEW BRILL STREET CAR TRUCK.

A New Arc Lamp.

We present illustrations of the new Brush-Adams arc lamp just announced by the Brush Electric Company of Cleveland, O. This lamp, the manufacturers state, has been designed from a users' standpoint, and the arc lighting companies will find it extremely interesting. All springs that can in any way influence the arc have been abolished and thus one chief cause of uneven and changing adjustments is eliminated, No glycerine, oil or mercury is used. The frame of the lamp is entirely and durably insulated from the working parts. Unless a hanger board is desired no hood need be used as the lamp is weatherproof. Hanger boards, globes, jackets, rod protectors, etc., are all alike for single and double lamps, and a large saving is thus made to lighting companies in the stock of spare parts required to be kept on hand. The method of securing the globe upon the lamp is interesting and seems effectually to prevent the blowing off of globes or breakage from heating or drops of melted copper from the carbons. No thumbscrews, which so often crack the globes, or drop out and loosen them, are used, and it is claimed that the flaming arcs which sometimes occur when the lamps are about to cut out, cannot possibly cause breakage of globes. An excellence that will be quickly appreciated, especially in "hot trimming" is seen in the ease and rapidity with which the globe can be removed and placed out of the way.

The careless trimmer who intends to clean the globe "to-morrow," will with this lamp be "moved" to do it to-day, and he cannot be troubled by sleet or dust sticking to the globe-holder.

The Brush-Adams lamp is adjusted to a standard current and voltage and no means of changing this adjustment is provided. The current required is stamped upon the lamp and with this current the manufacturers claim that it will burn with perfect steadiness and reliability on any circuit throughout the country. Lighting companies and the public suffer much from readjustments made by careless, incompetent or tinkering employés. The adjustments of the new Brush lamp need never be changed, or if required to be altered for a different current, must be changed with special but inexpensive tools provided by the manufacturers.

Cleanliness of arc lamps is necessary for perfect working, but is often neglected in dusty or smoky locations on account of the difficulty of cleaning, involving in the old forms the taking down and apart of the lamp. The new lamp is so constructed that while in its ordinary burning position in the street or elsewhere the rods, clutches and other parts requiring cleaning can be slipped out quickly and put back without any soldering or other work.

Another feature is the arrangement of carbon rods and clutches. The clutches are expected to be as durable as any other part of the lamp, and the rods do not require to have the true round surface usually necessary, as the bearing surface of the self-cleaning clutches will feed a rod, even when pitted or scarred or worn. The cut-out is positive and sure, and a very effectual device is provided for preventing the "lapping" of carbons and for insuring the lighting of the lamps, whether trimmed with the carbons apart or in contact.

The jacket, though tight, can easily be removed. The exterior finish of the standard lamp is black japan with bronze trimmings, the idea being that the user can bronze or ornament this surface for special purposes if necessary. The bright brass lacquered finish of many lamps, while showy when new, is difficult and expensive to renew. The hangerboards, alike for single or double, indoor or outdoor lamps, are provided with a strongly made switch arranged to close one circuit before the other is opened, to prevent arcing, and to cut the lamp entirely out of circuit when switched off.

Equipment of the "Trenton."

When the United States warship Trenton visited Corea a few weeks ago, she carried into that harbor the first electrical installation ever seen there, and the first that the natives ever heard of. Immediately after her arrival at the port the Coreans flocked to her sides in their sampans, and many of them were allowed on board. They expressed great surprise and wonder at the many fine things they saw during their visit, and were delighted. When night came, however, and the electric lights were set going, they were filled with astonishment and awe. They were shown the electric bells, annunciators, torpedoes, etc., and at once they believed the foreigners were in league with the devil. A native would be told to press a button, and a bell would be heard ringing at a distance, whereupon the whole company would rush to that part of the ship to see who was ringing it. Finding no one there they would attribute the phenomenon to be an evidence that the evil spirit reigned over the vessel. Some of the visitors made ineffectual attempts to prevent the ringing of the bell by grasping the wire tightly in their hands, hoping in that way to head off the evil one who was playing such freaks for their amusement. An electric primer, immersed in a bucket of water, was surrounded by half a dozen dirty denizens of the benighted isle, while another native was told to push a button at a distance, whereupon the primer exploded, throwing water all over the surprised party who were looking eagerly into the bucket. Some incandescent lamps were lowered far down into the water, and being suddenly lighted, no one being near, the natives were filled with horror, and hurried away from the devil and the Trenton.

Special Correspondence.

NEW YORK NOTES.

Office of The Electrical World,
167-177 Times Building, New York, Nov. 3, 1890.

Seib & Starke are bringing out an improved electric door opener.

The Crocker-Wheeler Motor Company is as busy as ever. Many motors are under way, of all sizes, and for all kinds of application.

A very interesting talk by Prof. Sheldon on the "Magnetic Current" was given at a recent meeting of the department of electricity of the Brooklyn Institute, which has its temporary quarters in the lecture room of the Young Men's Christian Association. A large number of members were present.

The Consolidated Electric Storage Company has issued a neat little circular, giving the cost in detail for installing electric light plants for private residences, hotels, factories and the like. All the necessary data for the Julien storage battery and other apparatus required are given in a convenient form.

The Collins Ball Ore Separator Company, 45 Broadway, New York, under the management of C. M. Ball, is now exhibiting a model separator run by a Crocker-Wheeler motor. It performs its work most ingeniously and perfectly, separating the pure metal from the base, and it is claimed that over 75 per cent. of pure metal can be separated by this machine.

The United States Electric Railways Company is a new organization that has recently been incorporated, and is now established in comfortable quarters at 10 Wall street, this city. Primarily, it is an electrical engineering company, and will contract for and build electric railways, steam plants, power plants, and anything and everything in that line. An important part of its business will also be the reorganization of street railway companies that desire to equip with electricity, and the negotiation of the bonds for the necessary capitalization. The president of the company is Wolston R. Brown. W. L. Clark is special counsel for the company, and Lemuel Wm. Serrell, will be general manager. The well-known financial standing of the gentlemen forming the company, combined with the long experience of Mr. Serrell in electrical engineering work of every sort, ought to be sufficient guarantee of the thoroughness of the new company's equipment for doing every sort of electrical work, and we hope that the enterprise will be rewarded by as active a business as could be desired.

Electrical People in Town who registered at Alexander, Barney & Chapin's Electric Exchange, in the Telephone Building, 20 Cortlandt street, this city, form a long list during the past week. Among the names appear those of: E. H. Clark, Long Branch, N. J.; Rudolph Schmidt, Rochester, N. Y.; C. A. Nichols, Springfield, Mass.; J. Pinckney Smith, New Orleans, La.; A. D. Newton, Hartford, Conn.; M. E. Baird, Windsor, Conn.; W. C. McIntire, Philadelphia, Pa.; A. H. Hayes, Newark, N. J.; Romeyn Boyden; H. E. Harrington, Hartford, Conn.; J. F. Noonan, Paterson, N. J.; J. H. Shay, Chicago, Ill.; J. W. Pachard, Warren, O.; J. W. Peale; Wm. Whitney Monroe; O. S. Carr, Greenpoint; G. F. Bulen, New Jersey; Leo Daft, New Jersey; W. R. Eckert, San Francisco; George W. Davenport, Boston, Mass.; P. L. Salstonstall, Boston, Mass.; Wm. H. Temple; Fred. H. Whipple; George W. Adams, Boston, Mass.; W. R. Bennett, Hoboken, N. J.; J. H. Bunnell; C. R. Huntley, Buffalo, N. J.; Wm. M. Brock, Paterson, N. J.; Frank Wheaton, Paterson, N. J.

Exhibit of Primary Batteries.—James H. Mason, 120 Park avenue, Brooklyn, has opened a very fine exhibit of his electrical specialties in the new Arcade, Fulton and Johnson streets, Brooklyn. His electric search light for general use, which uses a 16 c. p. incandescent lamp run from 12 cells of No. 9 battery, is shown. He has also on exhibit a handsome newel post statue holding a three c. p. lamp run from four cells of No. 9 battery, each of which is 7 × 5 inches. A small motor running a revolving stand uses only one cell of No. 9 battery. The exhibit also comprises the Bennett acoustic telephones, electric motors running fans from a single cell of No. 9 battery, electric bells, switches, medical batterics, etc. The booth in which the exhibit is made is elaborately fitted with reflectors, with Edison one c. p. lamps of various colors, and some of these are also suspended from the ceiling of the booth. Mr. Mason also shows a fire alarm system of his own invention. One of his No. 11 batteries is shown running an Edison phonograph. His new Giant cell has a prominent place in the exhibit. This cell is composed of prepared carbon, a slot being made in the top for the introduction of the zinc. These cells are said to give 2½ volts and 40 ampères for half an hour. W. T. H.

NEW ENGLAND NOTES.

Branch Office of The Electrical World,
Room 8, Cook Building, cor. Franklin and Congress Sts.,
Boston, Nov. 1, 1890.

Mr. H. W. Chase has recently connected himself with the Standard Electrical Supply Company, of Boston.

Mr. Theo. Mosher, of the Mosher Arc Lamp Company, of Chicago, is on a business trip through the East, and is receiving many compliments on the efficiency of his new lamp.

The Rowell American Switch Company reports an increasing business. It has opened an office at 319 First National Bank Building, Chicago, and is now engaged in filling some large contracts.

The Yale & Towne Manufacturing Company, at Stamford, is building about one-half a mile of track around its factories, and will use Edison motors and Wheeler's trolley hangers and other devices.

New Bedford, Mass.—The subscribers to the stock of the new co-operative electric lighting company of New Bedford held a meeting recently and formed a temporary organization with James M. Lawton, Jr., as president.

Mr. Alexander P. Wright, of the the Wright Engineering Company, of Boston, sailed last week on the "City of Chester" for England, having been unfortunately called suddenly home by cable announcing illness in his family.

A Little Mica.—A recent report from Lynn states that the weekly demand for mica at the Thomson-Houston factories is no less than 3,000 pounds. Mica, it will be remembered, was one of the things thoughtfully taxed by the McKinley bill.

Electric Welding.—Mr. O. C. Hall has been appointed superintendent of the Thomson Electric Welding works, to succeed Mr. Tregoning, who has gone abroad for the purpose of establishing works of the Thomson Welding Company in some available English city.

Another Good Word for Electricity.—The New Haven, Conn.) committee on streets has recommended that the legislature grant the horse railway companies of that city the privilege of using electricity to propel their cars. This is another evidence of the grip the electric street railway is getting in every city that shows symptoms of modern enterprise.

The Wheeler Trolley.—Frank Wheeler, Meriden, manufacturer of the Wheeler double trolley devices, etc., has met with great success, his invention having been received with much favor. At present the Equitable Electric Railway Construction Company, of Philadelphia, is installing four of his trolleys at the Baldwin Locomotive Works for use on two traveling cranes which are capable of hoisting 100 tons each, and when completed will be the largest electric hoist in the world. Each crane is operated by two of his four-wheeled trolleys. L. H. H.

PHILADELPHIA NOTES.

Branch Office of the Electrical World,
31 City Building, Philadelphia, Nov. 1, 1890.

High Brothers & Co. are putting in a 12 h. p. Payne engine to run the dynamos for the Crosscup & West Engraving Company.

W. S. Griffith & Co. are installing a 25 h. p. arc light plant for the Knoxville inclined railway at Pittsburgh, Pa. The work includes wiring and the construction of a series of electric signals.

The Star Electrix Company, of Philadelphia, has just increased its capital stock to ten times the original amount. At present it manufactures switches, gas attachments, insulating joints, cut-outs sockets, and incandescent electric supplies of nearly every kind, and its success has been so gratifying as to necessitate a great increase in its capacity.

Objected to Overhead Wires.—The Board of Highway Supervisors, Philadelphia, rendered decisions recently in a number of cases where application had been made for the erection of poles and the laying of conduits to be used by electrical companies along various streets. In every case the board disapproved of the erection of poles but granted the right to lay conduits.

Removal.—A large increase in business has compelled the Moore & White Company to seek more commodious quarters, and to that end it has purchased a lot on the northeast corner of Fifteenth street and Lehigh avenue, where it has erected a suitable building for its business. It has recently been filling large orders for friction clutches and other power apparatus.

Electrical Cigar Cutter.—A decidedly novel application of the electric motor may be seen in the cigar store of Dalton & Mann, of Philadelphia, where the ordinary cigar cutter is replaced by a Perret motor operating a revolving knife inside a neat case. The tip of the cigar is merely thrust through one of the holes in the case, and is promptly sliced off. The arrangement was installed by Mr. Cleverley.

The Otto Gas Engine Company has just shipped a 50 h. p. engine to the Hamilton Gas Light and Coke Company, of Hamilton, O., which has put in a new incandescent plant, and proposes to give the gas engine a chance. Another 50 h. p. Otto engine has been sent to the Aurora Gas Light Company to operate the Fort Wayne Jenney incandescent lamps. Two other engines of large size are under way for contracts with gas light companies who propose to add electricity to their present apparatus. W. F. H.

WESTERN NOTES.

Branch Office of The Electrical World,
465 The Rookery, Chicago, Nov. 1, 1890.

Mr. Frank A. Magee, of New York, is taking good care of the interests of The E. S. Greeley & Co. in Chicago this week.

Mr. Oscar Ericsson, superintendent of the Cascade Milling Company, of Sioux Falls, South Dakota, was in Chicago last week securing the needed supplies for an increase in the dynamo capacity of his station.

The South End Electric Railway Company has been formed at Chicago with a capital stock of $100,000 for constructing street railways, the incorporators being F. H. Deych, C. J. Wood, and C. E. Loose.

Shut Down for the Winter.—The electric fountain at Lincoln Park, this city, which has been greatly admired through the summer, is now shut down for the season, as the park is going into winter quarters.

Mr. Charles E. Brown, of the Central Electric Company, has just returned from an extended trip of over eight weeks' duration. Mr. Brown reports business good, and brings home some nice orders for improved Candee wire.

The Illinois Electrical Material Company, of Chicago, is receiving many orders for its Murray overhead railway switch, which seems to have met a long felt want, and to have taken particularly well among street railway managers.

Chicago Electric Club.—The next regular meeting of the Chicago Electric Club will be held at the rooms, 103 Adams street, Monday evening, Nov. 3, commencing at 8 o'clock. The papers of the evening will be "Underground Electrical Work," by F. E. Degenhardt, and "Street Railways," by Theo. P. Bailey.

The Electrical Engineering and Supply Company, 413 Jackson street, St. Paul, Minn., is fitting up handsome store rooms, and will shortly be prepared to look after the supply business in the Northwest. Mr. C. A. Daigh, formerly with the Northwestern Thomson-Houston Company, is the president and general manager of the company, and Morgan Brooks, of the St. Paul Gas Company, is the secretary and treasurer.

The Jenney Electric Motor Company, of Indianapolis, has appointed Mr. Henry C. Eddy as its Chicago agent, and a more suitable appointment could hardly have been made, as Mr. Eddy has a wide acquaintance among the business men, is energetic, and stands well with the electrical fraternity. With a live representative to push so excellent a motor, "the Jenney" ought to become a familiar sight in Chicago.

They Have Come to Grief.—The Suburban telephone and telegraph companies around Chicago have struck a snag in the recent action of the commissioners of public works. A vigorous effort was made to erect poles on Sixty-first street, without proper authority. The committee of citizens took hold of the matter and the permits of the offending companies were revoked until an investigation can be made. The overhead wire is only tolerated in the suburbs of Chicago, and the feeling of the citizens is strong against it.

Telephone Quotations.—Col. S. G. Lynch, broker, 153 Monroe street, Chicago, furnishes quotations on telephone stocks as follows:

Chicago	$298@$300	Cumberland	$ 59@ $60
Central Union	60@ 62	Wisconsin	117@ 118
Michigan	94@ 96	Bell of Missouri	155@ 160
Great Southern	32@ 35	Iowa Union	20@ 21
Colorado	38@ 40	Missouri and Kansas	55@ 57
Rocky Mountain Bell	40@ 45		

ELECTRIC LIGHT STOCKS.

Chicago Arc Light and Power	$95@$100	Chicago Edison Co	$130@$132

F. DE L.

ENGLISH NOTES.

Special Cable to "The Electrical World"

London, Nov. 3.

The City & South London Railway will be formally opened tomorrow by H. R. H. the Prince of Wales. Regular service, however, will probably not begin for a couple of weeks. The line is three miles long, double track, with six stations. There will be a five-minute train service. Each train will accommodate about 100 passengers, and consists of a 100 h. p. electric locomotive drawing two cars. The voltage used is 500, as usual in America. The municipal stations at Brighton and St. Pancras will be inaugurated this week. The Grosvenor Gallery station will close this week, and the entire load will be taken by Deptford. Thirty miles of the Ferranti mains have been laid, and out of 8,000 joints only 15 have proved defective. The military authorities propose to light the camp at Aldershot by electricity.

(From our own Correspondent.)

London, Oct. 22, 1890.

Rapid Telegraphy.—Attention was recently called in the daily press to a remarkable instance of rapid telegraphy. The Exchange Telegraph Company of this city published a brief but graphic description of the scenes which occurred in the cemetery on the recent occasion of the funeral of Mrs. "General" Booth. These tape messages were being rolled off at all the London clubs at 2:20 P. M., the funeral having passed through the city at 2 P. M. and the cemetery being then four miles distant, the Exchange Company was therefore on this occasion a little "too previous."

The City and South London Railway.—The delay which is occurring in the opening of this electric railway has given rise much unfavorable comment in the daily press. I understand that one cause of the delay has been the decision of the engineers to line the inside of the steel tubes with brick in order to diminish the reverberations. There are also difficulties in connection with inward leakage of sewage. I have mentioned before, I think, that Messrs. Mather & Platt, the electrical contractors of this company, propose making the axles of the locomotives the armature shafts of the motors. The success of this line will doubtless give courage to electrical engineers in this country to tackle the question of electric traction on the Underground Railway, which although a simple problem to those who know nothing about the facts of the case, is a very difficult one to solve. Confidence in the electromotor is on the increase in this country, and in a conversation with an eminent electrical engineer, well-known in the electric traction world, he told me that he would have no hesitation in attacking the work to-morrow, if necessary.

News of the Week.

THE TELEGRAPH.

Decatur, Ill., is to have a district telegraph service. It is backed by Mr. W. B. Burke, the electrician of one of the plants in the city, who has obtained an ordinance for right of way for poles and wires, and proposes to push the construction and system at once. The plan includes police and fire alarms, as well as messenger service. For the fire alarm work it is proposed to have the fire department connected with the central office, so that an alarm can be turned in from the house of a subscriber almost instantly.

A New Brotherhood of Telegraphers has recently been organized, having its starting point in Chicago. It has suddenly grown to a rather powerful organization in the city, and trouble with the Western Union Telegraph Company is brewing. The new brotherhood purports to be a secret, beneficial and protective organization, composed of railway and telegraph operators. It resembles very much the brotherhood of 1883, except that it has affiliated with the Federated Railway Employés instead of the Knights of Labor. It is presumed that this means avoiding the competition of railway operators in case of a strike.

THE TELEPHONE.

The Shaver Corporation is doing some vigorous work in pushing its telephones in Northern New England. It has already an exchange in operation in Littleton, N. H., one is being started in Berlin Falls, N. H., and a company has recently been organized to operate in Hillsborough county, to put in private instruments and exchanges.

THE ELECTRIC LIGHT.

North Braddock, Pa., will soon have a full-fledged electric light system. The Citizens' Electric Light Company is now placing its arc and incandescent lines through the suburbs.

Mr. J. Almstead, superintendent of the Rochester Electric Light Company, Rochester, N. Y., will increase the capacity of his station by adding 500 h. p. in Leffel turbines, and probably the Westinghouse alternating incandescent apparatus.

Mr. A. H. Bauer, Chief Electrician of the Pullman Company, is replacing all porcelain shades with etched glass, as the latter afford a much richer appearance with less absorption, and a better diffusion of the electric light employed in train service.

Isolated Plants.—Mr. C. J. Thomson, Western agent for the Continental Dynamo Company, reports the installation of two isolated plants in St. Paul, Minn., one 250 light plant at the St. Paul High School, and a 30-light machine at the St. Paul Linseed Oil Company.

J. F. Calling, who for a long time has been with the Excelsior Electric Company, and later superintendent of the Consumers' Gas Company, of Danville, Pa., has just been appointed to the management of the Powelton Electric Company, a new organization which has a franchise for lighting nearly all of West Philadelphia.

The Westinghouse Electric and Manufacturing Company has concluded a very excellent record of contracts for the month of October. During the first three weeks of that month the company had orders for the furnishing of alternating current incandescent electric lighting apparatus approaching a capacity of 25,000 16 c. p. lamps. This is a very good showing in itself, though the contracts for arc light apparatus, street railway apparatus and electric mining appliances are not included in this. Contracts for central station alternating current incandescent apparatus were received from the following places: Evanston, Ill., 750 lights; Baltimore, Md., 6,000; Elmira, N. Y., 1,500; Oswego, N. Y., 750; Durango, Col., 750; Lincoln, Neb., 1,500; Orange, N. J., 750; Uxbridge, Mass., 750; Tampa, Fla., 750; Cohoes, N. Y., 750; Manchester, N. H., 1,500; Amesbury, Mass., 500; Aransas Pass, Tex., 750; New Cumberland, W. Va., 750; Mason City, Ill., 500; Havana, Cuba, 750; Rich Hill, Mo., 750; Clearfield, Pa., 500. Among the places where Westinghouse alternating current arc apparatus was installed dur-

ing the month are: Oswego, N. Y., 60 lights; Clearfield, Pa., 25 lights; Washington, Pa., 60; Norwich, N. Y., 25; Baltimore, Md., 250.

APPLICATIONS OF POWER.

Champaign, Ill.—The first electric car on the Champaign-Urbana Railway made a successful trip Oct. 20, and the line will soon be put in full running order.

Electric Car Stations.—A vigorous kick is being made by some of the residents of Albany over the proposition to have electric cars stopped only at certain stated spots, on the ground that carrying passengers by their places of business in this fashion would be an out-and-out damage to them.

Electric Railroads.—A bit of hard pan common sense concerning the electric railroad comes drifting up from Texas, where the Houston *Post* remarks that it would pay to grant electric street car franchises for a period of 100 years much better than to cling to the mule system for another decade.

The new power house of the Pittsburgh, Allegheny and Manchester Traction Company, on Juniata street, Allegheny, will be completed by the first of February. During the excavation for this structure a vein of very valuable building sand was struck, the product of which was disposed of to Pittsburgh contractors.

Rochester, N. Y.—The Short electric railway system is rapidly getting into operation, and a number of electric cars have already been put into service. The street railway company is anxious to begin full operation as soon as possible, and as the people are much pleased with the new system there is every reason to believe that the company will find its receipts very gratifying.

Operating Bridges by Electricity.—So much trouble has been experienced with exasperating delays owing to the slowness of operation of the drawbridges in Chicago that city electrician Barrett has recently proposed to operate them by electric motors. He says that power can readily be furnished for 16 of the principal bridges and the annoyances of delays be very materially abated.

McKeesport, the biggest borough in western Pennsylvania; Braddock, famed as the seat of the Edgar Thomson Steel Works; and Wilmerding, the rising new town created by the Westinghouse Air Brake Company, are to be connected by electrical rapid transit within the course of the next year. A company is being organized to erect the main line, and it is expected that actual work will begin before the end of the year 1890. There will be some pretty stiff grades along the route, but this fact is not believed to be a serious drawback to the venture.

Industrial and Trade Notes.

Brown & Sharpe Manufacturing Company has just issued an excellent little pamphlet on the use of emery wheels, giving a number of excellent hints as to the manipulation of the wheels for various sorts of work, and a description of its own admirable apparatus.

Bateman & Pollard, East Twenty-third street, New York, the popular wiremen and contractors for electric lighting and power work, are very busy in the installation of several large plants, as well as in repair work.

Julien Dennison has lately installed a 100-light U. S. Dynamo at the factory of the Seamless Rubber Co., New Haven, in connection with the Evans friction devices. Mr. Dennison has now in New Haven and vicinity 54 of his motors all working successfully.

The National Manufacturing Company, through Mr. L. N. Cox, its Washington special agent, has recently closed contracts for electric light plants at Newberry, S. C., Chester, S. C., and Tarboro N. C. A street railway at Tarboro is also to be constructed.

Wilmot & Hobbs, of Bridgeport, Conn., have just been distributing to their friends a neat little pamphlet containing a table of wire gauges in decimals of an inch, tables of weights and measures, and various data and facts that are convenient for everybody.

Charles H. Hardick, manufacturer of the well-known Niagara steam pumps, has just issued an elaborate catalogue describing various types of power pumping apparatus that he manufactures. It contains nearly everything in the line of pumps that modern requirements have made necessary.

The E. P. Gleason Manufacturing Company, manufacturer of all kinds of glass work for arc and incandescent lighting, shades, bulbs, arc globes, etc., and maker of gas and electric fixtures and fittings for all kinds of incandescent lighting, as well as other specialties—is very busy in its various lines.

The Crosby Electric Company, 87-89 South Fifth Avenue, New York, is still hard at work putting its house in order for the exhibition of its open and closed circuit batteries for all kinds of electrical applications. When its salesrooms and new shops are completed it will have a most attractive display.

The Jewell Belting Company ha taken the contract to equip the entire outfit of belting for the new power station of the Rochester Street Railway. This company has sold within two weeks one 50-ipch three-ply and one 54, one 44, two 24, three 18 and four 16-inch double belts, and over 1,200 feet narrower double belts

The New York Insulated Wire Company, more popularly known as the "Grimshaw," 649-51 Broadway, New York, has sold many thousand feet of wire for the most popular buildings throughout the United States; but lately it has received an order for wire to be installed in what can be said to be the most noted building in the country—the White House.

The Boughen Engineering Company, of Cincinnati, O., reports the installations of the steam apparatus required in connection with the electric plant in the following places: Tell City Woollen Mills, Tell City, Ind.; H. & S. Pogue Company, Corryville Ice Company, and Hotel Mitchell, of Cincinnati, O. This company is also building the water-work plants at Huntington, Ind., and London, O.

Wallace & Sons, 29 Chambers street, New York, manufacturers of soft and hard drawn copper wire, and also brass and copper rods, sheet, tube, etc., are offering their special hard drawn copper wire for electric railway trolley wire, and it is said to be equal to silicon bronze for conductivity, tensile strength and durability. This is one of the oldest firms in the city in this line of business, established 'way back in the Forties,

The Evans Friction Cone Company has a capital exhibit at the Mechanics' Fair in Boston. It is shown in actual operation driving Thomson-Houston dynamos, and attracts a great deal of attention by the great compactness and good mechanical properties of the plant. Mr. Evans himself has most carefully superintended the exhibit at the fair, and it is, unquestionable, one of the most complete and well-arranged plants in the entire building.

Steam Economizing.—The vacuum exhaust steam economizer of the American Tube and Iron Company seems to have been meeting with considerable success recently. A letter lately received by them from one of their customers reports better success in heating the feed water than in any similar apparatus that has been tried, and emphasizes this endorsement by requesting the company to "hustle about and send the second order immediately."

The Knapp Electrical Works, 54 and 56 Franklin street, Chicago, are mailing to all applicants a very handsome catalogue and price list of electric light and electric railway supplies, house goods, telegraph instruments and district messenger apparatus, etc. There are over 200 pages between the covers; the classification and arrangement of the various lines is creditable and will prove of convenience to the purchaser, and the entire work is so well done that it will long be treasured by the fortunate recipients.

The Easton Electric Company, 45 Broadway, manufacturer of the Claus-Easton dynamo, is very busy making dynamos and generators, to meet the many orders secured by Mr. Peter Claus, of the company. They have made many improvements upon Mr. Claus' dynamo from suggestions and designs of his own. They are also going to bring out a new design of dynamo and motor. They manufacture arc, incandescent dynamos, motors and generators, and contract to install the same for both central stations and isolated plants.

The Central Electric Company is showing a piece of plain Okonite wire that was placed in the Lumber Exchange building at Minneapolis five years ago, and has been used continuously ever since. The wire was stapled to the fire-proofing and plastered over, and is now apparently in as good condition as ever. Okonite seems to become more popular with architects and electric light men each year and has so far withstood the severest tests that have been applied to it. The Central people have a stock of fully 2,000,000 feet in their ware-rooms.

The Swain-Goodsell Metallic Packing Company, 139 Lake street, Chicago, desires to furnish a sample of the Swain Metallic packing to the superintendent or engineer of every electric light station in the country. For steam feed rods that are in good condition it will prove cheaper than other packing on account of its adaptability to rods in ordinary condition; simplicity and ease of adjustment; avoidance of wear on rods; no disconnecting of cross-heads in applying; ease of removing when desired, and economy and durability as shown by results.

The Waste Oil Filter Company, 322 Pearl street, New York, are putting out their filters quite extensively among the electric light plants in the United States and Canada. These filters are of the best in the market; and they have testimonials from Edison, Westinghouse, Thomson-Houston, as well as from many central stations speaking in the highest terms of their successful operation; in the saving of many barrels of oil, as well as cleansing waste oil in a perfect manner—in many cases the testimonials mention the fact that the oil is purer after passing through the filter than originally.

Goulds' Manufacturing Company has just issued a neat descriptive circular calling attention to its new triplex electric pump, which has been meeting such favorable reception during the short time it has been working itself into general use. The pump, as is well known, can be fitted, if desired, to any ordinary type of motor, and is now made in all capacities from the little domestic pump requiring ⅛ h. p. motor up to a 10 h. p. machine capable of pumping 200 gallons a minute. The good qualities of these pumps have already made them so favorably known that they can hardly fail to find an increased application wherever electric power is convenient and a pump is needed.

Blauvelt, Joy & Blauvelt, successors to Blauvelt & Haldy, 258 Broadway, New York, are the owners of a patent oiler bearing for dynamos and high-speed machinery shaftings. The beauty of this device is an oil-well that is connected with the bearing in which there are two single or double rollers which carry the oil on to the shaft, and keeps the bearing constantly lubricated. They are selling shop rights to manufacturers of dynamos, high-speed machinery, etc. This company also manufacture the Mitchell transpositive sign for the display of goods in electrical supply houses. An attempt to describe the same would be useless. We would advise our readers to send for their illustrated circular and description.

The Connecticut Motor Co. continues to enjoy a great run of prosperity; very large orders have lately been received from the West and South and overtime is the present motto. The new 50 h. p. generator is being well received. The Connecticut Electric Co. through A. M. Young has purchased a 400 h.p. Compound "Ide" engine from John Post, Jr., New England agt. for their Waterbury station, also an 80 h. p. 500-volt Thomson-Houston generator; the demand for lights at this station has increased during the last few months remarkably and extensive additions have become necessary.

The Goodyear Hard Rubber Company and the India Rubber Comb Company, established in 1851, are said to be the oldest manufacturers of hard rubber goods in the world. They claim to be the owners and sole manufacturers under patents of Charles Goodyear, during their existence. The experience of almost 40 years in the details connected with the manufacture of hard rubber, and their large facilities and extensive works (among the largest of the kind in the world) enables them to produce goods of any quality, shape or compound, important to the demands of the trade. They make a specialty of every kind of hard rubber insulating goods for electrical purposes, and can manufacture them in any quantity, variety or sizes. They are thoroughly equipped for the execution of all orders. They give particular attention to exactitude, high finish and superior quality, for which they have established a good reputation. Their storage battery cells can be had in any size or design, on short notice.

The Taylor Manufacturing Company, of Chambersburg, Pa., reports the following recent sales of its "Beck automatic engines" for electrical purposes: The sale of the fourth 125 h. p. engine to the Watervliet Turnpike and Railroad Company, of Albany, N. Y., together with complete steam plant for increasing the capacity of their electric railway plant, which has proven to be one of the most successfully operated electrical street systems in the country; one 13 × 15 engine, with boiler, to Taylor Bros. & Hall, Macon, Ga.; to Gregory & Co., California, two engines; engine with complete steam plant to Curwensville (Pa.) Light and Power Company; one engine to Union Feed Company, Chattanooga, Tenn.; one 8½ × 10 engine to Singerly Paper and Pulp Company, Elkton, Md.; complete steam plant for Citizens' Heat, Light and Power Company, Blairsville, Pa.; complete steam plant to Schuler & Co., Meridian, Miss.; 7 × 8 engine for Western Electric Company, New York; 9½ × 12 engine for Anglo-American "E. C." Powder Company, of Oakland, N. J.; two 9½ × 12 engines for Manhattan Bank Company, New York; 10 × 10 engine for steamer "Susquehanna," New York; 14 × 15 engine for Chas. Gossage & Son, Chicago; 11½ × 15 engine for Niles Electric Light and Power Company, Niles, Ohio; 12½ × 15 engine for McKeesport Light Company, McKeesport, Pa.; two engines through Boughen Eng. Co., Cincinnati, of their vertical styles, one to Western Electric Company, of New York, for driving dynamos for lighting a circus for Robert Solton, of Mamaroneck, N. Y., and to Hipley & Son, of Allegheny, Pa. These vertical engines are highly recommended by all those who have used them, and they are guaranteed to give entire satisfaction, driving any type of dynamo or for other isolated work.

Answers to Correspondents.

Questions to be answered in this column must be of general electrical interest, and must be accompanied by real name and address as a guarantee of good faith. No notice will be taken of questions regarding apparatus unless enough details are given to permit a definite answer, and no dynamo or motor designing will be done.

Iron for Armature Cores.—(1) Would Russia sheet iron be as good as any easily obtained to construct a laminated armature core? (2) Can you refer me to a good book on dynamo construction for beginners, giving practical rules for designing? E. C. C.

(1) Russia sheet iron properly annealed will answer very well, though any soft charcoal iron will serve the purpose. (2) Hering's "Dynamo-Electric Machinery," which can be obtained at this office, if not otherwise easily available, will be perhaps as satisfactory as any book we could recommend you.

Constant Current vs. Constant Potential Motors.—To furnish 50 h. p. to stationary motors located one mile from generator, what advantages, if any, would 500-volt motors in multiple have over motors run in series on a constant current circuit of 6.8 ampères? ELECTRIC LIGHT.

The answer to this question would depend somewhat on what work your motors were to do. The constant potential motors regulate rather better than the constant current motors, and are likely to disturb the generator less when the load varies. With a number of small motors constant current gives good satisfaction provided very close regulation is not necessary. For larger work—several horse power, for example, to each motor—we should prefer the constant potential motors. The cost of line would, of course, be less with the constant current.

Business Notices.

Battery Cut-Out, Cheap.—Sensitive, reliable, never requires attention. Gas lighting much improved by its use. Electric Supply Co., of 105 South Warren street, Syracuse, N. Y.

To All to Whom these Presents May Come, Know Ye.—By a resolution duly passed by the corporation known as "Hazazer & Stanley," it was voted to change the name of said corporation, with permission of the court, from "Hazazer & Stanley" to "Stanley & Hall."

Now, by order of the Supreme Court, it is made known that from this time the name of said corporation is and shall be "Stanley & Hall." A. F. STANLEY, President.

Through Vestibuled and Colonist Sleepers Between Chicago and Tacoma, Wash., and Portland, Ore.—The Wisconsin Central and Northern Pacific lines run through Pullman vestibuled and Colonist sleepers between Chicago and Tacoma Wash., and Portland, Oregon. The train known as the "Pacific Express" leaves the Grand Central Passenger Station, at the corner of Fifth avenue and Harrison street, at 10:45 P. M. daily. For tickets, berths in Pullman or Colonist sleepers, etc., apply to Geo. K. Thompson, City Passenger and Ticket Agent, 205 Clark street, or to F. J. Eddy, Depot Ticket Agent, Grand Central Passenger Station, corner Fifth avenue and Harrison street, Chicago, Ill.

OUR ILLUSTRATED RECORD OF ELECTRICAL PATENTS

U. S. PATENTS ISSUED OCT. 28, 1890.

439,092. Guide for Trolley Arms; Arthur F. Bardwell of Boston. Assignor of one-half to Herbert H. Brooks, of Cambridge, Mass. Application filed May 15, 1890. In accordance with this invention outwardly-extended flaring-arms are pivoted one at each side of the trolley-wheel, said arms being normally held in a horizontal position by the action of a spring, so that they will catch on the trolley-wire when the wheel leaves it, and thus prevent the arm from flying into the air, the said arms having at their outer ends upwardly-extended projections which prevent the trolley-wire from sliding off the said arms.

439,102. Electric Motor; Charles S. Bradley, of Yonkers, N. Y. Application filed July 5, 1890. An electric motor for alternating currents, comprising an armature and field magnet, the latter having its circuit alternately partly closed on itself and partly included in the line circuit, the former or closed portion constituting a secondary circuit of self-induction and repelling the armature, while the latter constitutes a primary circuit and attracts the armature.

439,1 1. Dry Battery; Wilhelm Louis Frederik Hellesen, of Copenhagen, Denmark. Application filed March 2, 1890. A battery element consisting of two receptacles shut by a common cover of impervious material, the outer receptacle being provided with holes at the bottom part, the inner receptacle having holes at its upper part, the space between both receptacles being filled with porous substances and the inner receptacle being covered by a layer of porous material and filled with a sticky substance which surrounds an electrolyte protected by a porous bag.

439,178. Method of Repairing Incandescent Electric Lamps; Casimir Pauthonier, of Paris, France, Assignor to the Society l'Incandescence Electrique, of same place. Application filed June 7th, 1890. The process of repairing the filaments of incandescent lamps, which consists in the introduction into the lamp containing the broken filament of a liquid or gaseous hydrocarbon, bringing together two of the sundered ends of the filament including the joint for the purpose of welding the ends by the deposit of carbon, then bringing together the other ends of the filament, and then passing a current through the filament.

439,180. Electric Elevator; Francis B. Perkins, of Boston, Mass. Application filed Feb. 5, 1890. The combination, with a drum-elevator mechanism including a worm-shaft, an electric motor having its armature shaft connected to the said worm-shaft, and a brake mechanism to control rotation of the said shafts, of an electromagnet connected to said brake mechanism, an armature for said magnet, a rod, connected to said armature, a cam to act on said rod, a shaft on which said cam is mounted, a switch lever or arm on said shaft, a resistance-box connected to the motor, and a shipper-wheel and rope.

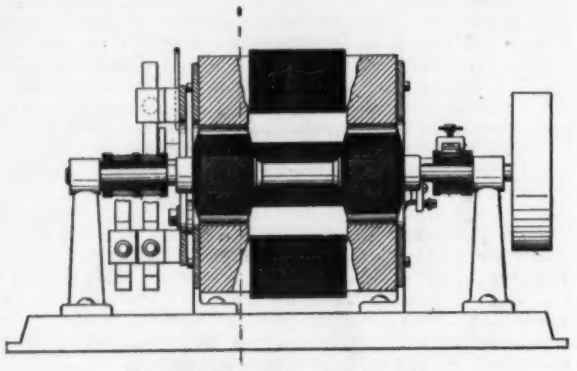
439,182. Trolley-Pole; Louis Pfingst, of Boston, Mass. Application filed July 14, 1890. The invention consists in a combination of a disc mounted on the car-top with a horizontal arm pivoted at the centre of said disc, a trolley-pole pivoted to the free end of said arm, and a tension spring connecting said pole and arm, said pole being inclined outward toward the car end.

439,192. Trolley-Pole for Electric Cars; Benton C. Rowell and Francis E. Galloupe, of Boston, Mass. Application filed April 5, 1890. In combination with the trolley-pole of an electric car, a pair of diverging movable arms connected therewith, one upon either side of the trolley, with the inner limits or diverging parts of the arms in proximity to the respective edges of the periphery of the trolley, and a cord which passes through a guide near the end of the trolley-bearings attached to said arms, whereby their diverging portions will be moved to a position above the trolley when the cord is pulled.

439,213. Electric Magnetic Clutch; Curtis Hussey Veeder, of Lynn, Mass., Assignor to the Thomson-Houston Electric Company, of Connecticut. Application filed June 27, 1890. The invention consists of a clutch or brake mounted on a shaft and constructed in the form of a double cylinder similar to a Camacho magnet and a wire coil occupying the annular space between the two cylinders, the armature or piece to be attracted consisting either of a similar electromagnet or of a disc adapted to be attracted axially by the before-mentioned magnet.

439,237. Apparatus for Transferring Electric Car Batteries; Frederick G. Corning, of New York City, N. Y. Application filed Aug. 5, 1890. The combination in a battery-transferring apparatus, with a horizontal surface or way upon which the batteries are moved, of a revolving bench at a level with said surface upon which the batteries are received and their positions reversed with reference to a given direction of travel.

439,238. Electro-Dental Heater; Luther Ashley Faught, of Philadelphia, Pa., Assignor to the Wilmington Dental Manufacturing Company, of same place. Application filed July 23d, 1890.



NO. 439,102.—ELECTRIC MOTOR.

An electro-dental heating device having a lamp mounted therein and connected with a source of electric energy, and a cap provided with a recess for receiving a point or artificial crown.

439,240. Method of and Apparatus for Preparing Electrodes for Secondary Batteries; Charles D. P. Gibson, of Jersey City, N. J. Application filed March 8, 1890. The method or process of manufacturing secondary battery plates, which consists in associating with metal plates or holders an active material or oxide and then immersing said plates on conducting-shelves into an electrolyte, and connecting said shelves to a source of current.

439,262. Electric Railway; Lawrence Westerland, of Atlanta, Ga. Mary C. G. Westerland, Administratrix of said Lawrence Westerland, deceased. Application filed May 31, 1890. An electric railway in a conduit formed of two parts seated together on corresponding taper bearings and having a slot between them at their tops.

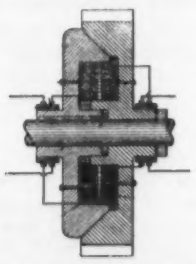
439,295. Recording Signaling System; Wm. James Fraser, of Milwaukee, Wis. Application filed May 17, 1890. In recording signaling system, a record-receiving surface, distant transmitting machanism embracing electrodes grouped to conform to a character to be transmitted, an electric circuit extending from said record-receiving surface to said transmitting mechanism, a shifting stylus for marking upon said record-receiving surface, mechanism controlled by a magnet upon said circuit for shifting said stylus parallel to said record-receiving surface at intervals corresponding to the grouping of said electrodes.

439,301. Secondary Electric Battery; Jacob F. Mehren, of Chicago, Ill Application filed Jan. 20, 1890. A plate or element for a secondary battery, having a series of perforated supports for the active material integrally united, the external side surfaces of the plate being formed of the edges of the supports.

439,304. Electric Lamp Socket; John Otis Phillips, of New York, N. Y. Application filed Feb. 5, 1890. The combination with two separable parts of an electric lamp socket, of a lock comprising a stationary ring secured to one of the separable parts and provided with an angular slot, a pin secured to the other of the separable parts and adapted to enter both the slots in the said rings, whereby the separable parts may be locked without rotation relatively to each other.

439,308. Automatic Wire-finder for Trolley Heads; George S. Slocum, of Newport, R. I. Application filed June 2, 1890. In combination with a trolley-carrier, a finder pivoted thereto, and means for causing said finder to rock by the making or breaking of an electric current through contact of the trolley wire and finder.

439,324. Secondary Battery; Edward J. Mason, of Waterford, Canada, Assignor of three-fourths to Frank Brown Allan, Elias Edw. Slaght and John William Thompson, all of same place. Application filed Feb. 20, 1890. A battery comprising a soluble electrode composed of a series of iron plates coated with copper, a



NO. 439,213.—ELECTRO-MAGNETIC CLUTCH.

depolarizing electrode composed of a series of plates containing peroxide of lead, and an electrolyte of sulphate of copper in a solution containing free sulphuric acid.

439,345. Electric Locomotive; Francis W. Dean, of Cambridge, Mass. Application filed July 15, 1890. In an electric locomotive, the combination, with the truck-frame and its axles and supporting wheels, of an electric motor having a revoluble shaft, and mounted upon and movable vertically with said frame, a system of pulleys, each provided with a series of circumferential grooves, and a series of ropes constructed and arranged to transmit the motion of the motor shaft to the axles and wheels, one of said pulley being constructed and arranged to be automatically adjustable for taking up the slack of the belts.

439,347. Electric Belt; John Franklin Fields, of St. Ignace, Mich. Application filed March 29, 1890. The combination of the cells, each composed of an inner element, an outer element bent upon itself in U shape around the inner element, but not in contact therewith, and having its ends which project beyond the end of the inner element confined or clasped together to retain the inner element in position, with the links connecting the inner element of one cell with the outer element of the opposite cell.

439,363. Electric Lamp; Alfred Swan, of Orange, N. J., Assignor by direct and mesne assignments to the Insulite Manufacturing Company, of New York City, N. Y. Application filed March 5, 1889. The combination, with an electric lamp having a threated nipple extending from its base of the holder having a threaded socket for receiving said nipple, a wire entering the base of the holder, and a screw plug for binding the wire to the holder

439,364. Incandescent Lamp Socket; Alfred Swan, of Orange, N. J. Assignor by direct and mesne assignments to the Insulite Manufacturing Company, of New York City, N. Y. Application filed April 22, 1889. An electric lamp socket consisting of a base and contracted neck, a lamp support on the base at the end opposite the neck, and a switch moving about said neck within the circumferential area of the base.

439,365. Incandescent Lamp Socket; Alfred Swan, of Orange, N. J., Assignor to the Insulite Manufacturing Company, of New York City. Application filed Nov. 27, 1889. In an incandescent lamp socket, the combination, with the body provided with contacts for the line wires of a neck forming a part of the socket and supporting the body from the line-wire carrier, said neck being open at the side to permit of access to the line wires inside the neck.

439,366. Incandescent Electric Lamp Socket. Alfred Swan, of Orange, N. J. Assignor to the Insulite Manufacturing Company, of New York City, N. Y. Application filed June 6, 1890. In a switch, the combination, with the circuit-closing devices and a spring for breaking the circuit, of a sleeve having cam-surfaces and a key rotating within said sleeve and formed in two parts, one part being provided with a cross-pin engaging said cam surfaces and having a longitudinal movement independent of the other part when returned by the circuit-breaking spring, the key being constructed with lost motion between the two parts, in their rotary movement, substantially as described.

439,367. Incandescent Electric Lamp Socket; Alfred Swan, of Orange, N. J., Assignor to the Insulite Manufacturing Company, of New York City, N. Y. Application filed March 5, 1889. The combination, with an incandescent electric lamp and its holder of a socket set into the holder, and receiving the end of one of the line wires, and a plug adapted to be screwed into the socket to bind the wire and to form contact with the base of the lamp.

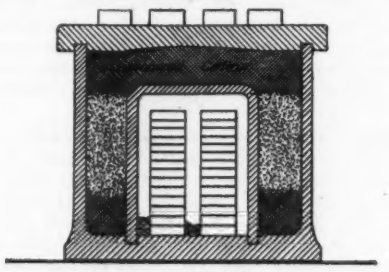
439,381. Electric Meter; William H. Bristol, of Hoboken, N. J. Application filed April 10, 1890. It consists in combining with a bar or needle, which is deflected by the current, a device adapted to engage with a movable arm or extension carried by said bar or needle and to vibrate it transversely to the plane of deflection of the bar or needle by the current, said transverse vibrations being transmitted and converted by purely mechanical means to actuate the mechanism of a register or counter.

439,389. Electric Lighting System; Thomas A. Edison, of Menlo Park, N. J., Assignor to the Edison Electric Light Company, of New York City, N. Y. Application filed Aug. 30, 1881. In an electric-lighting system, the combination of a main circuit having multiple arc branches containing one and two lamps, respectively, the filament in branches containing but one lamp being of standard resistance and length, while the filament in branches containing two lamps have approximately one-half the standard length, but have an area in cross section approximately twice that of the standard filament, whereby the radiating surfaces of the filaments are the same in the several lamps.

439,390. System of Electric Lighting; Thomas A. Edison, of Menlo Park, N. J. Assignor to the Edison Electric Light Company, of New York City. Application filed June 26, 1882. In a system of electric lighting, the combination, with a generator of electricity and electric lamps in two or more groups, of two or more secondary batteries in series with said generator and with each other, and switches connected with the charging or generator circuit and to the consumption circuit for disconnecting the batteries from the charging circuit and connecting them separately to a group of lamps.

439,391. Junction Box for Electric Wires; Thomas A. Edison, of Menlo Park, N. J., Assignor to the Edison Electric Light Company, of New York, N. Y. Application filed Aug. 7, 1882. The combination, with insulated electrical conductors inclosed in tubes, of boxes joining the tube sections, the joints between the boxes permitting expansion and contraction of the tubes.

439,392. Electric Lighting System; Thomas A. Edison, of Menlo Park, N. J., Assignor to the Edison Electric Light Company, of New York, N. Y. Application filed Aug. 22, 1882. The combination of one or more electrical generators and translating



NO. 439,393. CARBONIZING CHAMBER.

devices supplied therefrom of a safety catch for preventing injury to said generator or generators when their capacity is exceeded, and an alarm adapted to give notice of the destruction of said safety catch.

439,393. Carbonizing Chamber; Thomas A. Edison, of Menlo Park, N. J., Assignor to the Edison Electric Light Company, of New York, N. Y. Application filed Sept. 13, 1882. The invention consists in a vessel having a hollow space for containing the forms which hold the fibres to be carbonized, such space inclosed by walls of plumbago, and this in turn inclosed in outer walls of the same substance, the space between the inner and outer walls being filled partly with powdered plumbago tamped or driven firmly in, and partly with a material which combines with oxygen.

439,395. Velocipede; Richard J. Fleischer, of Tisch Mills, Wis. Assignor of two-thirds to Anton Langenkamp and Chas. Dederich, both of same place. Application filed March 21, 1890. In a velocipede, the combination, with a frame or platform carrying forks, pins or lugs, of a series of galvanic cells or generators and an electromotor on said frame or platform, a lever for varying the position of the brushes of said motor, a transverse rod extending across the top of the cells and connected to the upper ends of one of the metallic plates in each cell, and flexible connections connected to the ends of the rod and provided with enlargements or clutches to engage the forked pins or lugs.

439,398. Thermal Cut-Out; Calvin Goddard, of New York, N. Y. Assignor to the Edison Electric Light Company, of same place. Application filed Dec. 12, 1883. A safety catch plug provided with a conical tip-terminal, in combination with a socket or receptacle therefor having a corresponding depression in its bottom plate.

439,409. Railway Track Electrical Annunciator; Jacob William Lattig, of Easton, Pa. Assignor to the National Switch and Signal Company of same place. Application filed Aug. 21, 1890. In a railway-track annunciator, the combination, with a circuit and provided with a diaphragm adapted to be operated by air pressure to close said contacts of an air compressor adapted to be operated through the medium of the rack-rail by the weight of the car resting on or passing over said rail, and a connecting pipe leading from the air expelled from the compressor by the action of the car thereon is caused to operate the diaphragm.

439,416. Method of Making Storage Battery Plates; William Morrison and Louis Schmidt, of Des Moines, Ia., Assignors to the Hess Electric Storage Battery Company, of same place. Application filed Dec. 21, 1889. The method of making a plate for a second battery, which mode or method consists in first mixing nitric acid and protoxide of lead to produce a plastic composition, then drying or baking the composition, to make it hard, then filling a mold with the hard active matter particles, then heating the mold, then pouring molten lead into the mold and filling the vacant interstices with the lead, and allowing the mold and material therein to cool before removing the plate from the mold.

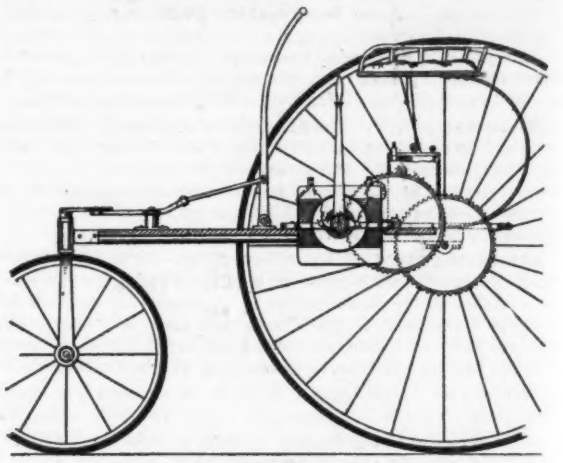
439,417. Automatic Regulator for Electric Currents; William Morrison, of Des Moines, Ia., Assignor to the Hess Electric Storage Battery Company, of same place. Application filed Feb. 17, 1890. The invention consists in the arrangement of sets of helices in pairs, the cores of which are opposite one another and having their like poles facing each other, said helices being connected in the main circuit, pivoted levers having a portion of their lengths connected to the bobbin on said helices near one of their ends, and depending plates or rods secured to their opposite ends, so disposed as to be suspended within a liquid resistance medium.

439,428. Electric Railway; Charles Richter, of Camden, N. J., Assignor to the Electric Construction Company, of New Jersey. Application filed Aug. 11, 1890. In an electric railway, a conductor composed of sections separated from each other and connected by switches, a motor with suitable contacts at each end for collecting the current from the conductor, and a magnet upon each car arranged to open and hold open the switches between the sections while the car is bridging the break, said switches returning by gravity to close the circuit after the car has passed.

439,441. Fire Alarm or Fire and Heat Indicator; Charles William Summerskill, of Hockley Heath, England. Application filed July 15, 1890. In a thermostat, the combination of an inclosing casing, air-tight expansible chambers, contact rod, thereon a screwed rod in axial line with said rod two terminals, one connected with the chambers and the other with a screw in the casing, a disc in threaded engagement with the screwed rod and a spring arm soldered to said disc and bearing against the screw in the casing.

439,459. Synchronous Alternating Current Electric Motor; Charles Zipernowsky, Maximilian Deri and Otto Titus Blathy, of Buda-Pesth, Austria-Hungary. Application filed May 11, 1889. A synchronous alternating current motor having a commutator and brushes for converting the current for the magnets into a direct current in combination with devices to temporarily short circuit the magnet windings at each reversal of the current, and a resistance or resistances in the supplying lead.

439,475. Mechanical Telephone; Hemburn M. Chamblin of Newton, Ill. Application filed May 10, 1890. The combination in a mechanical telephone of casing the and diaphragm, the line



NO. 439,395.—VELOCIPEDE.

wire, and a concave button secured to the end of the wire and having its concave side toward the diaphragm, the said button being provided with one or more openings.

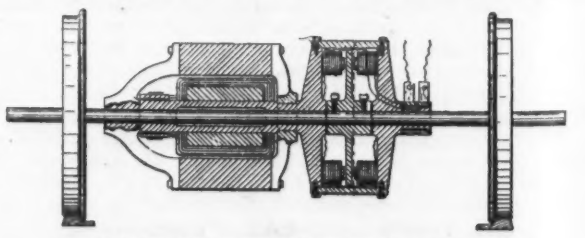
439,516. Porous Cup for Galvanic Batteries; Charles A. Hussey, of New York, N. Y., Assignor to the Crosby Electric Company, of same place. Application filed Aug. 29, 1890. A porous cup for batteries, provided with impervious sides or body portion, a contracted neck or orifice, and a pervious bottom.

439,584. Electric Railway Motor Car; Edmund Wagemann, of Little Rock, Ark. Assignor of six-sevenths to John D. Adams, Dean Adams, Oscar Davis, John W. Davis, Horace G. Allis and John B. Jones, of same place. Application filed Oct. 17, 1889. The combination of a car-body, beams lying longitudinally under and supporting said body, two pairs of car wheels and axles therefor and fixed thereto, box-bearings fastened to the said beams, tie-rods connecting said box bearings, and other tie rods connecting the said bearings to the extremities of the said beams, cylindrical ring armatures attached to the inner surfaces of the said wheels and concentric therewith, field magnet spools or tubular cores surrounding but out of contact with the said axles, and provided with pole-pieces on the ends and within inductive relation to the said armatures, the said pole-pieces being rigidly secured to the said spools and carried upon the said tie-rods, and with inductive relation with the said armatures at its upper portion, means, such as rings, for fastening the said tie-rods to the said pole-pieces, commutators mounted upon the said axles between the said wheels and the said spools, brushes pressing upon the commutators, and provided with handles hanging downward below the axles and within one's reach between said spools and the said armatures, rails for the wheels to run upon, and iron sleepers at right angles to the said rails, and connecting and supporting the same, the said wheels and pole-pieces being of iron.

439,587. Electric Motion Transmitter; Mark W. Dewey, of Syracuse, N. Y., Assignor to the Dewey Corporation of same place. Application filed June 23, 1890. The invention consists in the combination, in a mechanism for transmitting a reduced speed to a shaft or wheel to be driven, of a series of magnets connected with an electric circuit and arranged to be moved, a conductor arranged to move in proximity to the poles of said magnets, and a motor either the magnets or the conductor, while one of said parts is mechanically connected to the said shaft or wheel.

439,594. Secondary Battery; William B. Hollingshead, of Bronxville, Assignor of one-half to Sydney H. Carney, of New York, N. Y. Application filed May 29, 1890. In a storage battery, one element consisting of oxide of iron applied to iron or steel and having a suitable conductor, in combination with another plate or body of iron or steel also having a suitable conductor, and an electrolyte consisting of an alkaline solution.

439,597. Conduit for Electric Railways; Rudolph N. Hunter, of Philadelphia, Pa., Assignor to the Thomson-Houston Electric Company, of Connecticut. Application filed June 9, 1886. In an electric railway a stationary source of electric supply,



NO. 439,577.—ELECTRIC MOTION TRANSMITTER.

a bared electric working conductor arranged along the railway, a separate supply conductor electrically connected at intervals with said bared working conductor, and a slotted conduit inclosing the working conductor and forming no part of the electric circuit.

439,602. Electric Switch; John A. K. McGregor, of New York, N. Y. Assignor to himself, Herman Cohn, Edward Cohn, Henry Wallach and Solomon J. Wallach, trustees, all of same place. Application filed May 6, 1890. In an electric switch, the combination of two compact pieces, a slide carrying a bridge and a wing, and an inclined plane arranged in a line drawn parallel to the line of movement on said slide and through said wing and the free end of the adjacent contact piece secured, as described, so that when said slide is moved in one direction until a line drawn at right angles to its line of movement will pass through the contact piece, the wing and the inclined plane, said wing will be at one side of said piece and of the inclined plane, a portion of said plane will be between a portion of said wing and the contact piece, and all will be in contact, and when moved further the contact piece will engage the bridge.

439,624. Bell; Benjamin Egbert Vaughin, of Hill's Grove, R. I., Assignor of one-half to Frank L. Harris, of same place. Application filed July 23, 1890. The combination, with a case carbon and excitent of a post secured to the case, a bell, the inclosing sides, the magneto-electric hammer operating device secured to the case and binding posts constructed to form a self-contained electric bell.

Copies of the specifications and drawings complete of any of the patents mentioned in this record—or of any other patents issued since 1886—can be had for 25 cents. Give the date and number of patent desired, and address The W. J. Johnston Co., Ltd., Times Building, N. Y.